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China Report

SCIENCE AND TECHNOLOGY

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CHINA REPORT

SCIENCE AND TECHNOLOGY

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PEOPLE'S REPUBLIC OF CHINA

ABSTRACTS

NATIONAL DEVELOPMENTS

OPENING MARKETS FOR TECHNOLOGIES URGED

Tianjin JISHU SHICHANG BAO [TECHNOLOGY MARKET WEEKLY] in Chinese 9 Jul 85 p 1

[Article by Yang Jingheng [2799 4552 5899]: "Opening a Market for Technologies is Breakthrough in the Reform of Our S&T System"]

[Text] The resolution of the CPC Central Committee on the reform of the S&T system is of abundant content and profound meaning; we must implement this resolution. However, since the content is complex, where are we to make our breakthrough? Where is the "nose of the ox," which will enable us to get hold of the whole thing and gain mastery of the entire situation? In my opinion the breakthrough point has to be the opening of a market for technologies, because:

First, the technology market can most effectively promote integration of scientific research with production.

A technology market is a place to trade S&T achievements. The subject of the trade are commodities in the form of knowledge, comprising all kinds and shapes of industrial property rights, technical patents, technical information, technical services, training of personnel, engineering contracts, cooperative production, new products as the result of new technologies, etc. Just as all common commodities in physical form, intellectual commodities have value and use value, and are products of labor which can be exchanged. In the technology market, buyer directly meets seller, without restrictions as to departments, regions, military or civilian status, and without distinction as to ownership by the whole people, the collective or an individual. Production departments in urgent need of new technological armament can find suitable technological achievements in the technology market, and can also find parties willing to undertake technological development or to cooperate in problem-solving efforts. Scientific research units can find applications for the expansion of S&T results that they have already worked out, thus enabling these results to be soon transformed into productive forces. They will also discover many topics, on which work is urgently required by the production sector, and which they could then undertake to develop. The technology market can also be a place where S&T personnel can display their abilities in their particular technological specializations. Through trade activities in the technology markets, production and scientific research can establish close and diverse relations, and the serious evil of disjointed production and scientific research could be gradually overcome by technological market

activities, which will have the effect of promoting production as well as advancing scientific research.

Second, opening technology markets is the precondition for the reform of our system of allocating funds for scientific research units.

A crucial item in our present reform of the way in which our S&T is now organized is the reform of the system of allocating funds for our scientific research units. This reform demands that units engaged in developmental research gradually become basically self-supporting within 3 or 5 years in respect of their operating expenses. The purpose of this is that the change of the system of allocating funds will essentially motivate the scientific research units to link up with production, and that it will induce them to regularly and on their own initiative approach enterprises and the society in general in their search for research topics. By charging fees, through royalties on transferred technologies, by investing technologies as shares and sharing in the dividends or in any other way, the scientific research units should become economically linked with enterprise entities, remain bonded together through thick and thin and share weal and woe together. This would be a radical change from the past abnormal state of affairs, where scientific research units merely depended on the upper level department for their operating expenses, were responsible only to their superior departments and had nothing at all to do with society or production. However, if we want to accomplish this, there is no alternative but to acknowledge that technological achievements are commodities, which can be transferred against remuneration, can be invested in a company as shares, qualify for dividends and can be traded at negotiated prices, depending on their technological level, the economic results that can be derived from them and the conditions of supply and demand, thus providing the scientific research units with a comparatively solid economic income. Only with this precondition can the reform of the system of allocating funds be provided with an economic and material foundation. If we would merely emphasize self-sufficiency in operating expenses, but have technological achievements remain altogether unsaleable, also fail to create competition by opening technology markets, our reform of the system of allocating funds would amount to nothing but empty words.

Third, technology markets will help develop competition, will stimulate not only enterprises, but also those in charge of scientific research units as well as S&T personnel to exert greater efforts, and this will be beneficial for the raising and training of talents.

Distinctions depend on comparisons. When intellectual commodities enter the technology market with its free trade, they must face the fastidious selection by the buyers among the wares of several producers. Most welcome will be those technological commodities that yield high overall benefits, can quickly be converted to productive forces, the operation of which can easily be mastered, and that will produce products for which there is a broad market. On the other hand, research results that are purely pursuits of new technologies, but show no actual effectiveness or are far removed from realities, merely formulistic and theoretical literature without contributing to the solution of real problems of production, are bound to receive a very cold reception. There is, of course, the possibility that the value of some

particular research result with important theoretical implications and with potential for economic exploitation remains unrecognized by the buyers in the market, but if one is able to clearly publicize their long-term, inherent economic benefits, there will always be some people who recognize the worth of it. Furthermore, technological achievement of the same effectiveness and of equal level of attainment may get into completely different positions merely by earlier or later arrival on the market. This kind of realistic and sharply contrasting competition on the technology market will be a rigorous test for all scientific research personnel and for all those in charge of scientific research units. This type of competition is, of course, not the dog-eat-dog competition of capitalism, but still is competition in which the better one wins and the inferior is defeated. On the premise of a reformed system of allocating funds, defeat will have a profound impact on the unit and personal interests of the defeated party, and will stimulate that party to bestir itself, obtain fullest information, take advantage of the next opportunity and fight on bravely in the hope of being victorious in the next bout of competition. This type of competition will also have the effect of spurring on S&T personnel in their professional development. Incompetent people will be weeded out, and truly gifted ones will become apparent. Future criteria for the evaluation of the quality and the amount of contributions of technical personnel will be the result of comparison and selection in the technology market and the actual economic benefits created in the actual practice of social production; the traditional system of employing personnel on the basis of record of service and record of formal schooling will eventually die out by itself.

Fourth, opening a market for technologies will help implement the policies of "mutual dependence" and "correct orientation," beneficial for the promotion of uniting for combined action.

Opening a market for technologies will give rise to fierce competition between production enterprises. Certain inconspicuous small factories, weak in technological respects and manufacturing backward products, may possibly make a rapid advance and get ahead of all others in the quality of their products, in technological capabilities and in economic effectiveness by an opportunity to buy advanced technology in the technology market and by employing capable personnel. On the other hand, some illustrious big factory with a high level of technological capacity and a large personnel, could possibly become relegated to a position of inferiority in the competition because of its conservative technology, its giving itself airs because of age, while making no effort to progress, but rather cherishing the outmoded and preserving the outworn. The essence of all commodity competition is competition of technology, and the technological competition is essentially a competition of knowledge. In this type of competition the large number of our enterprise managers will be taught to gradually recognize the importance of knowledge, technology and qualified staff, and will thereby gradually come to respect knowledge and talent, and recognize the value of mutual competition to acquire advanced and useful technological achievements. Only then will the policies of "mutual dependence" and "correct orientation" become truly implemented.

Intellectual commodities are different from physical commodities in that they cannot be used as soon as they are bought. The buyer must provide certain

material and technical conditions and possess a certain level of knowledge, only then will he be able to make full use of the technological commodity. There has to be also a certain process of digestion, absorption and reconstruction. For this reason enterprises with comparatively developed capability for technological absorption are able to buy research results with a fairly high level of technology and yielding greater results; they can, furthermore, transform more effectively and more rapidly the acquired technologies into real productive forces. On the other hand, enterprises with poor ability to absorb technology will only be able to buy technological achievements of a lower level and with a weaker competitive strength, but such that are easier to operate, and even if they would indeed buy advanced, useful technologies, they would have great difficulties in transforming them into productive forces that can be managed by them. This is bound to lead enterprises to lay stress on strengthening their own capacity for technological development or to take the initiative of combining with units that have abundant technological strength, in order to assure themselves of long-term technological support. All these tendencies are beneficial for the strengthening of linkages between S&T units and production units, and will promote transformation of scientific research results into real productive forces at the utmost speed.

In order to achieve comprehensively the maximum of economic results, scientific research units must make efforts to fill in the gaps to complete a set of results, and for things that they can do themselves to achieve this, they should organize the efforts to do so. Whenever they are not capable of doing so, they may also, on their own initiative, link up with other technological units and jointly attack the problem. This trend of having sellers combine for joint action has already become evident at the present first national fair of technological achievements. In addition, in order to further facilitate S&T results becoming more acceptable and easier to manage by the production units, the scientific research unit will be induced to not only emphasize conducting experiments in the laboratories, but to also pay attention to obtain such results from central experiments that will increase the effectiveness of the technological achievement for production, in order to strengthen its ability to compete in sales on the technology market.

In brief, stressing the fact that technologies are commodities and opening markets for technologies are the crucial links which will have a certain effect of spurring on various important sections of the reform, such as changing the system of fund allocation, having each person work to the limits of his ability, strengthening enterprises in their ability to absorb and develop technologies, promoting linkages, motivating scientific research units toward consideration for production and the economy, having enterprises develop a strong inclination toward reliance on S&T progress and toward welcoming competition, etc. Taking these links as our point of breakthrough, we will be able to smoothly accomplish with comparative ease the all-round implementation of those parts of the "Resolution" that deal with the reform.

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NATIONAL DEVELOPMENTS

STRATEGIES FOR IMPROVING STANDING IN GLOBAL TECH TRADE

Beijing GUOJI MAOYI [INTERTRADE] in Chinese No 6, 27 Jun 85 pp 10-12

[Article by Hu Jun [5170 6511] and Zhang Bingshen [1728 3521 3947]: "The Challenge and Opportunity of the New Technological Revolution"]

[Excerpts] I. China's Position in Global Technical Trade

As science and technology made spectacular advances after World War II, the transfer of technology in the international market, commonly referred to as the global technical trade, also gained momentum. Technology is a specialized branch of knowledge which arises from combining systematic scientific knowledge with mature practical experience and operational skills. It includes rational knowledge, including principle, design, calculations, applications, debugging, as well as practical experience and operational skills. But this is technology in the form of knowledge. There is also a material form of technology which manifests itself in concrete objects such as machine tools and equipment. But to be useful at all, concrete objects like machine tools must depend on a specific operating procedure, such as testing and analysis. As a result, technical trade refers to the selling and buying of the knowledge of industrial production as well as the buying and selling of hardware like machinery and equipment. In global technical trade, China is at a disadvantage.

A. China Accounts for a Minute Share of Global Technical Trade

Global technical trade today is still concentrated in the hands of advanced industrial nations, with the United States, Japan and Western Europe accounting for 80 percent. The Soviet Union and countries in Eastern Europe account for 10 percent and developing nations, about 10 percent. China's share is less than 1 percent.

B. Deficit in Technical Trade

In global technical trade, the United States, Britain and France enjoy a favorable balance of trade, while Japan and the Federal Republic of Germany have been running up deficits. A deficit in technical trade does not accurately reflect a nation's standard of technology; despite their trade deficits, Japan and the Federal Republic of Germany are formidable technical

powers. They extensively import technology mainly to reduce the technical gap between themselves and other nations and fill the void in their technical know-how. China's technical trade deficit, on the other hand, is explained by its backwardness. Now and then it does appear in the international market as a seller, but our share of sales is tiny; we account for only 0.14 percent of the world's trade in electrical machinery goods, which is a gauge of a nation's technical standard.

C. The Structural Irrationality of Our Technical Trade

Since the People's Republic was founded, we have concentrated on the material form of technical trade. According to statistics, we spent about $14.5 billion importing technical hardware between 1950 and 1979, including $13.5 billion, or 93 percent, to finance the purchase of whole plants, and less than $200 million on the import of technology in the form of knowledge. Since its establishment, the Shenzhen Special Economic Zone has introduced 2,282 projects, of which 80 percent were labor-intensive, processing projects using imported materials. Only 20 to 30 projects, about 1 percent, were of a more advanced nature.

We have a deplorable record in converting imported technical hardware into technology in its knowledge form and back into hardware again. In Japan, the ratio between import costs and research & development expenses is 1:7, compared to 1:1 in China. It can thus be seen that reversing China's unfavorable balance of trade in global technical trade directly influences our position and role in international trade.

II. The Challenge and Opportunity of the High Tech Revolution

The high tech revolution presents a severe test of our position in the global technical trade as well as an excellent opportunity for change.

D. The High Tech Revolution Presents an Opportunity To Change Our Unfavorable Position in Global Technical Trade

Over the entire course of human history and scientific development, there have occurred several spectacular outbursts of scientific and technical creativity accompanied by shifts in scientific centers: From the discovery of fire to the appearance of multi-center ancient civilizations as a result of the development of stone, pottery and bronze technologies; the progression from pottery and bronze technology to iron technology, accompanied by the shift of the scientific center from the ancient civilizations to China; the leap from iron technology to steam technology, when Europe replaced China as a scientific center; the transition from steam technology to electric, atomic, computer and space technologies, when backward America took over scientific leadership from advanced Europe. The culmination of all these developments is the internationalization of science. This brief review shows that the course of human history and scientific progress, and the development of productive forces, are full of ups and downs, and that progressiveness and backwardness are relative concepts. Britain's science and technology were unsurpassed during the Industrial Revolution; today, however, it lags behind the United States and Japan in information technology, telecommunications and bio-

engineering. Learning from the economic experiences of advanced nations and directly adopting the latest science and technology, a backward nation is capable of catching up with and overtaking developed nations. The high tech revolution has presented us with just such an opportunity. Much of the latest technology since the 1970's did not spring from new scientific discoveries or inventions, but is a refinement and extension of existing scientific concepts and technology. Before the high tech revolution, therefore, both developing and developed nations are at the same starting point. Such is the belief of Toffler, an American sociologist. It is possible for us to join advanced nations at the same starting point, developing new industries or directly using new technology to develop new industries.

To be sure, all developed nations and a number of newly semi-industrialized countries and regions are now engaged in a scramble to develop new technology and concentrating on the production of state-of-the-art products, to the neglect of a large amount of traditional industries and technologies. We can use this opportunity to zero in on certain traditional technologies and products which have not yet become outdated, improving their quality and lowering production costs. In the process, we can, on the one hand, fill the void of traditional industrial technology and corner for ourselves that segment of the international market, and, on the other, provide the nation with technical personnel and funds to develop embryonic industries and open up a market for new technical applications.

III. Measures To Change China's Unfavorable Position in Global Technical Trade

We are a huge nation with gross imbalances in our economic, scientific and technical developments. Generally speaking, we still trail behind the world in science and technology, but areas do exist where our products are technically on a par with international standards. We should take this fact as our starting point when we map out our strategies.

A. Major industrial cities on the coast should rid themselves of the burden of traditional industries, develop high grade, precision and advanced products, and foray into the arena of global technical trade. This is because they have a high concentration of scientific and technical know-how, a strong industrial base and relatively well-educated workers, thus making it both necessary and possible for them to compete in the global technical market. At present, however, the industrial structures of these cities are still dominated by traditional industries; in both Shanghai and Guangzhou, for example, traditional industries account for more than 80 percent of their respective industries. Hemmed in by traditional industries and bogged down in an antiquated structure, the cities cannot release the human resources and funds required for developing new technology and industries. Hence they must overhaul the traditional industrial structure and retain and develop those traditional industries which still have potential, modernizing them technically so as to upgrade their products. In addition, they must conduct high-tech research and develop sophisticated products to gain entry into the international market.

B. Transform the Irrational Mix of Technical Imports and Enable Scientific Research Units To Play Their Important Roles

For a long time we have always considered foreign trade a means whereby nations supply one another's needs and regulate surpluses and shortages, ignoring the importance of using foreign materials and resources. This mentality has resulted in an irrational mix of technical imports: too much technical hardware, too little know-how. Moreover, we have also done poorly in converting technology from one state to another. Consequently, if we are to change our status in global technical trade, we must first rationalize the mix of our technical imports, assimilate thoroughly whatever we do import, convert them from a material state to knowledge and back to material state, and, through foreign trade, promote economic growth and raise our scientific and technical standards.

To change our position in global technical trade also depends on our domestic scientific and technical prowess and how it is put to use. In the past, the country's scientific research units were basically divorced from production enterprises and foreign trade agencies. Not only was our scientific research capacity relatively limited, but it was also underutilized. The results were that technical trade was deprived of powerful support in the form of technology and that technical imports were not assimilated and converted into knowledge and reconverted into hardware in time. We must therefore change this closed and inward-looking scientific research management system, orient scientific research units toward production and the international market, and enable them to play an important role in global technical trade.

C. Work Harder To Make Special Economic Zones and Economic and Technical Development Zones a Success

As transfer stations for China's foreign trade, special economic zones and economic and technical development zones should be further consolidated, developed and improved. In particular, we must make full use of their strengths: geographic location, close relations with key cities and abundant technical resources in their surrounding areas. At the same time, we must be selective in our technical imports, focusing on the capital of some multinational companies, license trade and patent technology, so that through cooperative production and cooperative research, etc., we can sooner come to grips with the new technology and develop a capacity to export technology.

D. Develop Intellectual Resources and Devote Major Efforts to the Development of Software Export

As computer technology advances, the pace of software development is also quickening. Software costs have increased noticeably and will grow to account for 90 percent of the total costs of a computer system. The popularization of the microcomputer in society, in particular, will create an enormous market for software. Each year Japan produces only 60 percent of the software it needs, with a 40 percent shortfall. In the West, the demand for programmers rises by 23 percent annually, while the number of people trained to develop software grows by only 17 percent. Many developing nations today consider the development of software for export the way to go in reversing an unfavorable

position in global technical trade. Software exports by India soared from $4.4 million in 1974 to $14.4 million in 1981, which translates into an average annual rate of 80 percent. Ninety percent of them were bought by the United States, Western Europe and the Soviet Union. China is in a uniquely favorable position to develop software. In the opinion of Japan's Fujitsu Corp, Chinese-made computers are of an extremely high standard. The company has placed orders for basic software relating to scientific computation using large computers, which it plans to sell to Japanese consumers. Confronted with a serious shortage of programmers, Japan is reportedly watching China keenly. For all these reasons, we must make the training of programmers a priority and consider it a strategy in an all-out effort to change our place in global technical trade and end the inequitable monopoly of technology by advanced nations.

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NATIONAL DEVELOPMENTS

DEFENSE INDUSTRY TECHNOLOGY GIVEN CIVILIAN APPLICATION

Beijing RENMIN RIBAO [OVERSEAS EDITION] in Chinese 14 Aug 85 p 1

[Report by correspondent Zhang Heping [1728 0149 1627]: "Transferring Defense Industry Technologies to Civilian Use is Urgently Needed and a Timely Aid to Economic Construction; S&T Departments of the Defense Industry Establish Long-Term Technical Cooperation With Beijing, Tianjin and Zhejiang"]

[Text] Our correspondent Zhang Heping reports that certain technologies of the defense industry, that had formerly been classified, are now widely made available for use in the four modernizations drive, much as the proverbial "sending charcoal in snowy weather."

This correspondent learned from departments concerned that new developments have occurred in the implementation by China's defense industry of the policy of "integrating army and civilians" and in the industry's promotion of the transfer of military technologies to civilian use: first, the transfer of single items of technology is expanded to the joint development of engineering projects; second, the cooperation in single items of technology is expanded to long-term and comprehensive economic and technical cooperation between departments and regions; third, the "forced marriage" type of administrative measures is gradually developed into a mutually beneficial "free union," primarily under regulation of the technology market.

This strategic shift was started with a technical cooperation with Tianjin Municipality. As early as in the summer of 1980, the Ministry of Nuclear Industry established a relationship of technical cooperation with Tianjin Municipality. In May 1983, S&T departments of the defense industry signed further agreements with Tianjin for economic and technical cooperation, establishing a long-term, comprehensive and diversified cooperation, which achieved very gratifying progress. Departments of the armament, aircraft and space industries signed 109 agreements with Tianjin, of which 82 projects involved have by now been completed. They increased the annual industrial output value by more than 160 million yuan and increased profits and tax revenue by over 20 million yuan. Twenty of these cooperative projects were of the level of advanced international technology. Successful experiences were made in economic and technical cooperation by the S&T departments of defense industry in its relations with Tianjin and by the Ministry of Ordnance Industry in its relations with Chongqing. The central authorities commended these relations, and these experiences began to be spread to all key cities. Since March of this year, the S&T departments of the defense industry signed

further economic and technical cooperation agreements with Beijing Municipality and with Zhejiang Province.

Toward the end of last year, the central leadership pointed out that technologies are commodities, and after opening a market for technologies, the S&T departments of the defense industry should boldly try the market out. At the "First National Fair For the Transfer of Military Technologies to Civilian Use," held in March of this year at Hangzhou, the results were beyond expectations. Eight technology trading groups of the defense industry system displayed more than 7,000 useful technologies, and over 3,200 items were traded on the spot; the total trade amounted to 1.12 billion yuan. For certain key plan items of the state and local authorities, tenders were invited, selecting only items that were employed with the best technical results. Among the trade negotiated at the fair, more than 100 items were of the 1 million yuan or more category, and 37 item among these were large projects of 10 million yuan and above. For instance, Huzhou City in Zhejiang Province had planned to spend U.S.$20 million on a new imported weaving machine, but learned at the fair that the Ministry of Aviation Industry had developed such machinery and had already put it into production. The two parties concerned finally came to an agreement, and the Ministry of Aviation Industry provided a machine for trial use.

At the "First National Technology Achievement Fair," held in Beijing in May of this year, the S&T related defense industry displayed more than 9,000 items, which represented about half of the exhibits on display at the fair. The amount of trade concluded reached the sum of 4.7 billion yuan, or about 60 percent of the total trade at the fair. Defense industry technology was much welcomed by the numerous medium- and small-sized enterprises, by village and township industries and by individual specialized households. As is evident from the two fairs, there are considerable prospects ahead for the transplantation of war industry technologies to civilian use. It is reported that during the period of the Seventh 5-Year Plan, the turning over of defense industry technologies to civilian use by the S&T sectors of the defense industry will concentrate on technologies related to energy sources, communications and transportation, light industry, chemical industry and medical apparatus and instruments, including hydraulic trestles for coal mines, petroleum machinery, aircraft, motorcars, motorbikes, air conditioners, electric refrigerators, television sets, washing machines, cameras, explosives for civilian use and other such standard civilian articles. It will also be the aim to open up the international market with technologically superior and hot-selling goods. In addition, it is also intended to provide useful technologies for the economic development of the remote border regions, such as Xinjiang, Ningxia and Nei Monggol. Persons involved in these matters have told this reporter that the S&T sectors of the defense industry, in the development of the production of civilian commodities, will actively seek foreign investments and welcome the cooperation of overseas Chinese and foreign firms. During the Seventh 5-Year Plan period, even greater developments are predicted in the transfer of war industry technologies to civilian use by our S&T sectors of the defense industry and by our ordnance departments.

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NATIONAL DEVELOPMENTS

CHINA'S CHEMICAL INDUSTRY IN 1983

Beijing XIANDAI HUAGONG [MODERN CHEMICAL INDUSTRY] in Chinese Vol 4, No 5 Oct 84 pp 2-5

[Article by the Office of Investigation, Ministry of Chemical Industry]

[Abstract] The gross chemical industry output value increased 11.4 percent in 1983 over that of the previous year with steady upgrading of the quality of the major products. Profits and tax payments of the entire industry increased 12.9 percent compared with that of the previous year, the increase in economic results were obvious. The consolidation of enterprises had shown marked effects. Around 32 percent of the enterprises had accomplished the 'five tasks of consolidation.' The consolidation of enterprise organization and product mix showed new progress. Completion of key construction projects were in good shape and many new technologies were continuously being developed. There were more than 70 major research projects showing good achievements. Further steps were taken with regard to the importance of nurturing qualified personnel.

[Text] In 1983, chemical industry workers, following the spirit of the 12th Party Congress, earnestly carried out the policy of "readjustment, restructuring, consolidation, and upgrading." Centering around economic results, they carried out the spirit of readjustment and restructuring a step further by the earnest development of enterprise readjustment and continuous quality improvement, thus obtaining gratifying achievements in establishing chemical industry production.

I. The Output Of Chemical Industrial Production Shows Broader Range

The gross output value of the chemical industry in 1983 reached 49.2 billion yuan (RMB), an 11.4 percent increase compared to the previous year (after subtracting the output value which was transferred to the General Petrochemical Corporation totaling 42.9 billion yuan, the increase over the previous year would be 11.9 percent). All 18 major products listed in the state plan have reached or exceeded production goals and showed different levels of growth compared with the previous year except for the production of pesticides and dyes. Amongst the 12 major products listed in the Sixth Five-Year Plan, seven of them, that is, phosphorus ore, synthetic ammonia, chemical fertilizers, H_2SO_4, caustic soda, rubber tires, and plastics have reached their goals 2 years ahead of schedule. (See Table 1.)

Table 1 Output of 18 Major Chemical Products in 1983

(Unit: 10,000 tons)

Product	Annual plan	Actual output in 1983	1983 Output %	Actual output in 1982	1983 as % of 1982
Phosphorus ore (output)	1010	1163.2	115.2	1172.8	99.2
(export)	1020	1158.6	113.2	1228.8	94.3
S-Fe ore (output)	550	735.5	133.7	619.9	118.7
(export)	610	753.3	123.5	650.2	115.8
Synthetic ammonia	1500	1677.1	111.8	1546.4	108.5
Chemical fertilizers	1255	1378.9	109.9	1278.1	107.9
Of which: Nitrogenous	992	1109.4	111.8	1021.9	108.6
Phosphate	260	266.6	102.5	253.7	105.1
Sulfuric acid	800	870	108.8	817.4	106.4
Concentrated HNO_3	20	25.6	128	24.6	104.1
Caustic soda	185	212.3	114.8	207.3	102.4
Soda ash	170	179.3	105.5	173.5	103.3
Pesticides	28	33.1	118.2	45.7	72.4
Of which: Highly-effective low-residue	14.7	18.7	127.2	15.0	124.7
Calcium carbide	150	180.7	120.5	147.4	108.7
Tires (10,000)	900	1271	141.2	863.6	147.2
Synthetic rubber	14.5	16.9	116.6	13.6	124.3
Plastics	96	112.1	116.8	100.3	111.8
Pure benzene	39	42.5	109	39.3	108.1
Methanol	39	43.5	110.8	38.6	111.9
Glacial acetic acid	16.1	18.9	117.4	15.5	121.9
Dyes	6.7	7.5	111.9	8.6	87.2
Paints	46	61.2	133	52.3	117.0

The quality of major products improved steadily. In the ministry-controlled quality index of 16 major products, 15 of them were equal to or better than those of the previous year, that is, a stable upgrading rate of 93.8 percent. The entire chemical industry system received national quality awards for 51 products, i.e. 7 gold and 44 silver medals. Another 251 items were judged by the ministry as good quality products. They Dyestuff Plant of Jilin Chemical Industrial Company was judged to be the nation's industrial and communications quality management advanced establishment.

The consumption of raw materials, fuels, and power has further decreased. In the ministry-controlled 25 major energy consumption indicators, 21 of them showed energy consumption less than or equal to that of the previous year, namely, a steady decrease of 84 percent. Energy savings in the entire chemical industry was about 1,600 thousand tons of coal, which was better than in recent years. Jiangsu Taichang Chemical Fertilizer Plant, Shanghai Solvents Plant, and Shenyang Rubber Plant No 4 are the nation's advanced units in terms of energy savings. There are 20 chemical industry enterprises rated as energy saving advanced units. Thirty-two units received commendations from the State Economic Committee.

II. Marked Increase in Economic Results

Total profits and payment of taxes from the chemical industry were 10.49 billion yuan, 12.9 percent more than the previous year (15.5 percent increase over the previous year before subtracting 8.14 billion yuan of output value which was transferred to the General Petrochemical Corporation), realizing an income increase greater than the increase in production. The entire industry reached a total of 8.84 billion yuan in profits and taxes, 9.2 percent more than the previous year (10.6 percent before subtracting 6.9 billion yuan for the transferred output value to the General Petrochemical Corporation). The growth of the chemical industry was about the same magnitude compared with other production units with an increasing rate 9.9 percent (10.5 percent after subtracting the transferred output value to the General Petrochemical Corporation). Profits and taxes per RMB 100 of total fund was 30.5 yuan, an increase of 2.5 yuan over the previous year; turnover period of quota circulating fund was 78.7 days, a decrease of 4.5 days over the previous year. Total labor productivity increased 8.4 percent compared with that of the previous year. Throughout the entire chemical industry, deficit was incurred in 515 enterprises in 1983 and 1,143 in 1982, a decrease of 54.5 percent; deficit decreased 60.8 percent from 0.408 billion yuan to 0.16 billion yuan. Obvious result is seen in small nitrogenous fertilizer industry by turning deficit to profit, deficit incurred in 304 enterprises fewer [than the previous year], a reduction of 0.143 billion yuan. The entire industry made 0.516 billion yuan net profit, which was 2.8 times increase over the previous year.

III. Effects Seen in Further Steps Taken in Consolidation of Enterprises

The year's all-out consolidation has enabled improvements in various aspects of enterprises, pertaining to personnel quality, skills and management in the chemical industry, resulting in a marked increase in economic results. About 32 percent, or 1,342 units of the total chemical industry have accomplished the 'five tasks of consolidation'. Of these, 199 units of key enterprises have passed the requirements; accounting for over 70 percent of the total number of key enterprises; and about 35 percent, or 13 of the ministry's production enterprises and construction, survey and design units have been checked. The spirit of the "four modernizations" of leading groups of all levels has been raised since consolidation. Based on 66 enterprise statistical units under the ministry, members of the leading groups were reduced 16.4 percent from 437 to 365, and the average age of cadres were lowered 5 years from 54.3 to 49.3 years. Cadres having a high school or college degree increased 21.4 percent from 47.3 percent to 68.7 percent. Based on checking the extent of achievements with respect to the "five working tasks," various departments in the industry have launched a widespread movement to construct "non-polluting" (Wu Xie Lau) [2477 3118 3345] and "modernized" (Wen Ming) [2429 2494] activity. By the end of the year, 308 "non-polluting" plants and 78 "modernized" plants were built, showing a great improvement in the image of the enterprise.

IV. Readjustment of Enterprises Showed New Progress

The entire chemical industry has been working on readjustment of enterprise organization and product structure to improve economic results for a year.

Many unqualified enterprises such as high-energy-consuming and non-competitive plants have been shut down at the request of the director of the State Chemical Department in 1982. For instance, there are 93 fewer small nitrogenous fertilizer enterprises than in the previous year. Another example is in Liaoning Province where, after an overall survey, 106 small paint producing plants were shut down due to work of poor condition and product quality, below the state standard, and this had a great impact on strengthening industrial management and raising social-economic results. In the readjustment of product structures, production of highly-effective low-residue pesticides has increased 24.7 percent to replace production of '666' (BHC) and DDT in order to reduce environmental pollution. In dyes, production of old products such as sulfur dyes, substantive dyes and levco dyes was reduced and replaced by more competitive products according to the market changes. In rubber products, production of motor [li(cosoo)] vehicle tires decreased while production of agricultural vehicle tires and a variety of rubber shoes were increased.

V. Major Construction Projects Were Finished With Improved Results

Under the guidance of the spirit of the Central Working Conference, all construction projects were to finish the current working program and exclude any items not in the plan, which kept investments within the state budget plan. The five major construction projects, the Beijing Dongjang Chemical Plant, the Yunfu Troilite Mine, the Shanxi Chemical Fertilizer Plant, the Zhejiang Zhenhai Petrochemical Plant, and the Urumqi Petrochemical Plant, were completed as planned. The synthetic ammonia and nitramine synthesis units at Heilongjiang Chemical Works; and the ethylene, ethanol, butaneoctaol, acetaldehyde, and acetic acid synthesis units of the Jihua Company; the catalytic cracking, net bag, and reinforced plastic manufacturing units of the Yanshan Petroleum General Corporation, and the fatty acid and fatty alcohol synthesis units at Dalian Oil and Fat Chemical Plant, all 12 of these engineering projects have been completed and put into operation. Besides, the urea production unit at Jihua Company and the cyanuramide synthesis unit at Sichuan Chemical Works were ready to be tested for production. The 6 construction projects including the Hubei Chemical Fertilizer Plant, the Qixiashan Chemical Fertilizer Plant, the hydrogen purifying unit at the Qilu Petrochemical General Plant, the Liuzhou Chemical Fertilizer Plant, the Wuhan Carbon Black Plant and the Xincheng Chemical Plant are now in the process of passing state evaluation. The preliminary designs for another 15 new plants have also been completed. The quality of basic construction engineering has shown marked upgrading, for instance, the Dongtinhu Chemical Fertilizer Plant has been awarded a prize by the state for good engineering quality.

VI. Chemical Technology Again Obtained New Achievements

In this year, under the combined effort of all S&T personnel and workers, more than 70 major research projects have shown good progress. Of these over 70 percent are projects to serve agriculture, light industry and defense. For instance, the production of P_2O_5 by the wet process using H_3PO_4 and $(NH_4)PO_3$ as intermediates; evaluation of a new soda ash diaphragm reactor and testing of a three-stage counter-current evaporator, etc. Some research topics are to be reported for the first time at home and abroad, and some have broken the

technological monopoly abroad. For instance, the research success in using a rare earth element as a catalyst for butadiene rubber production technology enables China to be the first worldwide; and the technology for the synthesis of vitamin E is a big success in precision chemical engineering, has broken the technological monopoly abroad, and its production unit is under construction in Beijing. New results have also been obtained with regard to the absorption and digestion of new technology from abroad. For example, a cooperative venture of the Nanjing Chemical Industry Company's Chemical Engineering Plant and Dalian Jinqhou Heavy Machinery Plant along with a foreign company has successfully constructed a 520-thousand-ton* urea synthesizing and washing tower up to international standards; and use of a largescale installation imported from France to carry out the decarbonization technique in ammonia synthesis improved the purifying ability by 15 percent and increased profit by 4 million yuan. Computer applications have shown new breakthroughs. For example, the Research Institute of the Nanjing Chemical Industry Company computer for monitoring alkylbenzene dehydrogenation at the Nanjing Chemical plant brought in 430 thousand yuan net profit in a mere 22 days; use of a microcomputer in the dealkylization of dichlorovos DDVP at the Nantong Insecticide Plant reclaimed 230 thousand yuan of investment. At the same time, the pace to replace chemical products has been stepped up, investments in manufacturing have been made to develop more than 600 new chemicals. Among them are top-grade dyes, coatings, perfumes, highly-effective low-residue pesticides, chemicals for leathers and paper manufacturing, and adhesives.

VII. Personnel Training Gained Recognition and Training Strength

In 1983, a total of 2300 chemistry majors in universities and 1596 high school and vocational students graduated from institutes directly under the ministry; 44 were sent for master degrees; and 57 went abroad for advanced study. Furthermore, enterprise units affiliated with the ministry provided training to 326 graduates from the Television University and the Workers University. As for the education of cadres, 937 leading cadres of: rotational training organs; provincial, municipal and district chemical offices and bureaus; as well as key enterprises, were trained at: the ministry's cadre management institute; the three special training centers for scientific research, capital construction and mines, as well as the Nanjing chemical machinery class. Seventy-one (71) cadres with college credentials attended special cadre training courses at the institutes of chemical engineering in Nanjing and Beijing.

Regarding the education of workers, incomplete statistics from the chemical industry bureaus of 14 large and medium-size cities, five major enterprises and enterprise institutes directly under the ministry indicate that amongst the 900 thousand workers, around 440,000 attended various cultural, service, or technical schools, reaching a school attendance rate as a whole of 50 percent. A total of 166 thousand persons qualified for remedial cultural courses, reach-

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[*Editor's note: According to the "People's Republic of China Year-Book 1984," p 388 -- "The Nanjing Chemical Industry Company successfully manufactured China's first urea synthesizing tower with an annual production capacity of 520,000 tons. The tower, 36 metres high and with an inner diameter of 2.8 metres, weighs 320 tons...."]

ing a cummulative 55 percent. Based on the remedial cultural course, various places popularize widespread remedial courses in technology to enhance the educational level of workers with middle school education. Just in the chemical industries in the 14 large and medium-size cities, 7,000 participated in higher education, of which 3,000 studied economic management.

VII. Tasks in 1984

Although, China's chemical industry in 1983 has obtained marked achievements, they were not sufficient. The major problems were relative to weak management, and poor quality of the chemical products. They were not meeting the needs of modernization whether it was due to the lack of resources in personnel, technology and management.

Major tasks to buildup production of the chemical industry in 1984 are: to thoroughly follow the spirit of the 12th Party Congress, to continue practicing "readjustment, restructuring, consolidation, and upgrading" to improve economic results, to improve product quality, to reduce energy consumption, to change deficit to profit, to improve the quality of enterprises, and to guarantee the completion of national projects. In order to accomplish the above-mentioned tasks, some suggestions are summarized as follows:

(1) overcome all difficulties to guarantee reaching production goals;

(2) continue consolidation of overall enterprises to guarantee the quality of work;

(3) take further steps to make up deficits and increase surpluses to eliminate management loss;

(4) build towards production with regard to work in new chemical technology to improve productivity;

(5) improve engineering quality to accomplish major national projects;

(6) improve the quality of working teams by upgrading the workers' qualifications; and

(7) tightly grasp the main points of enterprise restructuring.

(Paper received in May 1984.)

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NATIONAL DEVELOPMENTS

PATENT PROTECTION FOR CHEMICAL INVENTIONS DISCUSSED

Beijing ZHONGGUO ZHUANLI [PATENT REVIEW OF CHINA] in Chinese No 6, [Jun] 1985 pp 9-11

[Article by Shen Yaozeng [3088 1031 2582]]

[Text] Inventions in the chemical field mainly imply chemical substance inventions, but also include those of food and pharmaceuticals prepared by chemical methods. Patent protection for these inventions is a complicated issue that is handled differently among countries throughout the world. Only the general principles are outlined in the patent laws of our country. Although the criteria of examination for chemical inventions are tentatively set, they have to be constantly modified and perfected during their implementations in the future. In this article, a few questions concerning the patent protection for chemical substance inventions will be briefly explained.

I. What Are Chemical Substances?

Chemical substances are "substances obtained by chemical methods," which means new substances prepared by chemical reactions from starting materials that have different composition and properties from the latter.

Chemical substances, as defined by the patent laws, include:

1. Compounds that can be defined by molecular or structural formulars. They can be either low-molecular-weight inorganic or organic compounds that possess specific molecular weights and chemical and/or physical constants or polymeric compounds that possess no specific molecular weight and/or chemical and physical constant.

2. Substances that can not be defined by molecular or structural formulas but can be described by their preparation methods and/or chemical and physical properties. Examples are lignin, starch and cellulose.

3. Chemical intermediates, which means those compounds that have no valuable, direct uses except as materials for the preparation of other chemical substances (final products) by chemical reactions. Examples are organic reaction intermediates such as aniline, naphthylamine and phenosulsulfonic acid.

Mixtures and compositions are not regarded as chemical substances. Mixtures are substances consisted of two or more chemical substances, in which components are chemically inert to each other. Composition is a synonym of mixture and is often used in cases where two or more compounds form an homogenous entity that appears to be a single substance. Mixtures or compositions include:

1. Mixtures with specific uses. Examples are adhesives, detergents, polishing agents, lubricants, magnetic toners, coating materials, inks and paints.

2. Solid materials that appear to be pure compounds but in fact are mixtures of chemical substances. Examples are glass, cements, ceramics, fire retardants, explosives, plastics and alloys.

3. Macroscopic or microscopic structural mixtures. Examples are the layered products made of different materials, the safety glass having sandwiched layer of synthetic resin and the layered products made of pulp and synthetic fiber.

It should be pointed out that those mixtures by simple mechanical mixing of several chemical substances in which each component retains its properties without producing new applications or a mixture of several chemical substances in which only one chemical substance is active ingredient while others are either supporters or have no particular functions are not regarded as mixtures or compositions but are treated as chemical substances in the patent laws.

II. Why Chemical Substances Are Not Patentable in Our Country?

The various practices of patent protection for chemical substances in countries around the world are worthy of our careful consideration. The ways countries dealt with the issue of patent protection for chemical substances can be roughly classified into three modes:

1. "Absolute Protection" of Chemical Substances

"Absolute protection" means that, in the chemical field, it is handled the same way as in other fields that patent protection not only deals with a product per se but also includes the manufacture, sale and use of the product. This is mainly adopted by industrialized nations such as the United States, the United Kingdom, Canada, the Federal Republic of Germany and Japan. It worths mentioning that there was no patent protection for chemical substances in the Federal Republic of Germany until 1968 and in Japan until 1976.

2. Protection Only of Chemical Substances Having Specific Applications

This is to say that the protection of products in the chemical field is limited to the specific applications claimed by inventors or analogous applications. This is adopted by some industrialized Scandinavian nations such as Denmark, Norway, Sweden and Finland. The limited patent protection is adopted by these nations in order to enhance the development of their domestic chemical industries on the one hand and to protect the interests of these nations by keeping big foreign companies and enterprises from chemical product monopolies on the other.

3. No Patent Protection for Chemical Substances

This is mainly adopted by the USSR, the Eastern European countries and the majority of developing countries.

Through the analysis of the above-mentioned modes, two preliminary conclusions can be reached. First, we should move toward granting patent protection for chemical substances in the future because this is good for reaping the full benefits of the patent system. Second, the prerequisites of granting patent protection for chemical substances are that domestic chemical industries have achieved certain technological level and some products are competitive on the international market. Therefore, for the countries whose chemical industries are not developed and especially for the developing countries, it is inappropriate to grant the patent protection for chemical substances too early.

According to the regulations, the patent protection for a chemical substance covers wide areas. It covers not only the product per se but also all possible ways of manufacturing and using the product, even though the patentee does not envision them and mention them in the patent application. If a novel and innovative production process or application of the product is developed by someone else, the patent protection of which will be valid only with the consent of the patent holder of the product or after a compulsory license is obtained. For reasons that substances prepared by chemical methods cover wide areas and have significant implications, that there is a rather large gap in the technological level between our chemical industries and those of the industrialized nations and that we lack experience in dealing with this issue, it is appropriate at the moment not to consider granting the patent for substances obtained by chemical methods in order to protect our interests.

III. What Inventions in the Chemical Field Can Be Granted Patent Protection?

In our patent laws, inventions are divided into two categories, the product patent and process patent. In the chemical field, patent protections are granted to mixture or composition inventions of the product invention category even though there are no protections for chemical substances as well as food and pharmaceuticals prepared by chemical methods. Patent protections are granted for the following types of process inventions:

1. Production Process Inventions

Chemical substances can be made through one or more of the following chemical reactions: combination, decomposition, substitution and double decomposition in inorganic chemistry; addition, hydration, oxidation, hydrolysis, alkylation, carbonyl group synthesis, hypochloridation, chlorination, nitration, chlorine substitution, bromination, amination and ethylation in organic synthesis; polymerization reactions in polymer chemistry such as solution polymerizations, emulsion polymerizations and suspension polymerizations that are types of addition polymerization and all kinds of condensation polymerization reactions.

Those that can get patent protections are not limited to the new production processes of chemical substances. They can also be analogy processes. An

analogy process is a method to prepare closely related chemical substances from well-known chemical substances or closely related chemical substances that are new and well known by well-known process. These processes are not novel and the products, although new, are obvious. However, as long as the product possesses unexpected properties and hence finds specific applications, its process invention should be regarded as patentable.

Chemical recipes generally refer to methods of preparation and include the name, proportion and preparation condition of each component. They are accepted as belonging to the category of chemical process. These recipes can be granted patent protection as process invention. But if it is a "mixing recipe," that is the mixing of various chemical substances by certain proportions without changing the properties of the ingredients, then patent protection cannot be granted.

2. Processing Method Inventions

These inventions are all related to processes in which certain chemical substance is acted upon to achieve certain working objective. The chemical substance is not changed by the action, that is no other chemical substances are resulted from the application of this process. Examples are the analytical and testing methods, the purification as well as the transportation, quantitation, pellitization and refrigeration methods of chemical substances.

3. Process Inventions that Employ Chemical Substances for Specific Uses (Application Inventions)

These inventions involve the new applications of a known product, equipment or process to achieve specific uses. An application invention can generally be regarded as a process invention in which a material is employed for specific use. For example, the use of fine coal ash as a new construction material is a new application of fine coal ash, but it can also be considered a process invention of using fine coal ash as a new construction material. Therefore, the inventor can file patent application for "the method of making construction blocks by using fine coal ash" from the point of view of the production process.

It is worth noting that the patent protection for process invention in our country is limited to the process per se because it is not stated in our patent laws that the patent protection for process invention also covers the product that is prepared directly by the said process. Nevertheless, it is stated in our patent laws that: "When an infringement dispute arises and the invention patent involved is the production process of a product, the individual or organization making the same product shall provide evidence of the production process by which the product is made." Therefore, the product made directly by the said process is protected to a certain degree.

In summary, the process invention has important significance in our patent protection practices because chemical substances as well as food and pharmaceuticals made by chemical methods are not protected in our country but the production processes of these products can be granted patents by the patent laws. In the chemical field, not only the process inventions involving the

production of various chemical substances and those involving the processing of chemical substances but also the analogy processes and application inventions are protected. Thus, process inventions are granted better protection in our country but the chemical substances involved are also protected to a certain degree. This is more in line with the reality of our country. As to the issue of whether or when to grant patent protection for chemical substances, it will be decided after the laws have been implemented for a period of time.

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NATIONAL DEVELOPMENTS

SODA ASH PRODUCTION IN CHINA DISCUSSED

Beijing XIANDAI HUAGONG [MODERN CHEMICAL INDUSTRY] in Chinese Vol 4 No 5 Oct 84 pp 41-43

[Article by Yang Manyi [2799 2581 3354] of Tianjin Soda Ash Plant. "Doubling the Production of Soda Ash Should Be Targeted to Satisfy the Needs of Society"]

[Text] The 12th Party Congress stated: "China's economic objective from 1981 to the end of the century is to improve economic results to quadruple the gross industrial and agricultural output,...." This is a great strategic goal to push forward socialist modernization construction. This is a serious question and needs to be dealt with seriously.

In the author's opinion, the goal to strive for quadrupling the gross industrial and agricultural output value is a collective one. However, it cannot be applied to every trade, profession and commodity in exactly the same way. It has to be considered with regard to solving the imbalance in the development of the national economy. We must gradually reduce some commodities in over-supply and increase goods in short supply to construct a new balance of the economy.

For so many years, the production of soda ash was not enough to meet demand and therefore it affected the development of the national economy seriously. Before the production goal is set for such a situation, it is necessary to fully evaluate the problem of domestic shortage and the large amounts of passive annual imports. The production goal must be set to meet the society's soda ash needs gradually.

I. Evaluation of Soda Ash Production

From 1981 to the end of the 20th century, the production of soda ash was set to be 6∿6.5 million tons, that is, 4 times the actual output of 1.613 million tons in 1980, and this can be achieved with an average increment of 6.79-7.22 percent per year.

This is a plan without having considered our experience since the founding of the PRC nor the slow current demand. This plan cannot meet the needs of national economic development.

First, let's look back at the development of the soda ash industry since the construction of the nation. China produced 1.613 million tons of soda ash in 1980. This was 18.33 times more than the 88,000 tons produced during the years just following liberation and averaged an increment of 9.84 percent per year.

In the past 31 years, if we exclude the first 3 years right after the liberation and the 10 years of disturbance, the production of soda ash during normal national economic development increased an average of 12.8 percent per year from 223 thousand tons in 1953 to 1.066 million tons in 1966, and an average increase of 14.5 percent per year from 1.0754 million tons in 1977 to 1.613 million tons in 1980. During this period, we have not accounted for the loss of the Tianjin Soda Ash Plant caused by severe earthquake, otherwise, the average growth rate would be even higher.

Therefore, we can say that during the 31 years prior to 1980, the production rate of soda ash increased 12.8-14.5 percent per year in the normal economic development period, and even when we include both the 3 recovery years after the liberation and the 10 disturbance years, the average rate of increase was still 9.84 percent, and compared with the 6.79-7.22 percent progress rate for doubling the production to meet the state plan, the latter rate is still lower.

Next, the shortage of soda ash was hurting the national economy for many years, the growth rate to meet the demand for soda ash should have been faster than the actual growth rate of production. With a growth rate of 9.84 percent per year for the last 31 years, we have been paying a high price to import soda ash, but those imports still cannot satisfy our demand. Hence, this current plan to double production is also not fast enough.

Therefore, if the planned production of soda ash is simply based on the actual 1980 production value without regard to the historical development and the current needs of the society, then it will drag the hind leg of the nation's economic development by the end of this century.

II. Doubling Production of Soda Ash Should Aim To Satisfy the National Need

China is a socialist country and the goal of production in a socialist country is to fulfill both the material and cultural needs of the people.

In 1980, the actual consumption of soda ash was 1.9166 million tons based on 1.613 million tons domestic and 303.6 thousand tons imported. At that time, due to insufficient supply of soda ash, consumption was restricted by about 290 thousand tons, therefore, our demand in 1980 actually was 2.2 million tons of soda ash.

Obviously, we could just simply quadruple the actual production value of 1.613 million tons, using 1980 as an index, to 6.452 million tons, but such a plan would lead to a larger gap in production.

Of course, we can also forecast our demand in a certain period by means of statistics. However, in recent years the actual demand was hard to predict due to conflicts among soda ash production, demand, and the restriction of the

people's consumption. Hence, it is difficult to predict the actual need by the end of this century. Nevertheless we can estimate our demand based on trends of development and on direct and indirect consumption for other major products which need to use large amounts of soda ash.

The production of major soda ash related products and the gross output values in industry and agriculture since the Third Plenum of the 11th Party Central Committee are outlined in the following table:

Table 1. Some soda ash consuming products, gross industrial and agricultural output, and soda ash production growth rate ①

Item / Year	Plate glass output (10,000 cases)	Glassware for daily use output (10,000 tons)	Synthetic detergents output (10,000 tons)	Beer output (10,000 tons)	Gross industrial & agricultural output value (RMB 100 million)	Soda ash output (10,000 tons)
1979	2330	136	39.7	51	6175	148.5
1983	4167	269	67.7	163	9209	179.3
1979～1983 Average annual increase %	15.7	18.6	14.3	33.7	10.5	4.8

① data are quoted from REMIN RIBAO of April 30, 1980 and April 30, 1984

From the results in the above data, we find that since the 3d Plenum of the 11th PCC the growth rate of both the industrial and agricultural output, and the production of related products was faster than that of the production of soda ash. The gap between the needs and production is obvious. During this period of severe shortage, the amount of soda ash imported increased. By 1983, soda ash imports topped 600,000 tons which was 1/3 of the total output of the country. (See Table 2)

Table 2. Imports of soda ash since the Third Plenum of the 11th Party Central Committee

(10,000 tons)

Year	1979	1980	1981	1982	1983	Total
Import	16.63	30.36	21.18	24.09	60.35	152.61

We have spent over 0.3 billion U.S. dollars of foreign exchange in importing soda ash for the last 5 years: that is equivalent to more than 1 billion yuan of RMB including import tax and miscellaneous expenses. For China such spending is a heavy load on the national economy.

Judging from the above, there is no doubt that these major soda ash consuming products will continue to grow at a fast rate.

For instance, the production of plate glass was regulated to be 42 million cases in 1985 according to the Sixth Five-Year Plan, which would be 52 percent more than in 1980 with an average growth rate of 8.7 percent. Judging from the point of view of 3 years into the plan, 1983 shows an output value of 41.67 million cases which is close to the goal set for the Sixth Five-Year Plan. In recent years, the production of plate glass has been growing at 15.7 percent per year, which, however, meets only 40 percent of the current demand.

Much housing has been built in the cities and the countryside since the Third Plenum of the 11th Party Central Committee, and the demand for plate glass calculated from the total area of residential housing, public welfare facilities and other housing estimated for the Sixth Five-Year Plan was 63 million cases (based on 3mm thickness single-layer plate glass and 15 percent of the total construction area), which required about 600 thousand tons of soda ash.

In the case of glass for daily use, the production of beer in 1985 was set at 2 million tons; each ton of beer would require 1 ton of glass which also requires soda ash.

Furthermore, the demand for soda ash for synthetic detergents also increased 20 percent per year as based on the 20 percent increment per year for the first 3 years into the Sixth Five-Year Plan.

Of course, the demand for soda ash for some areas might not increase with the increasing growth rate of development and living standard. For instance, the demand for soda ash for foods might stay at a certain level. In general, the demand for soda ash for most trades and sectors increased at different levels with the increasing growth rates of product development and living standard.

Therefore, doubling the production of soda ash cannot be based on the actual output value of 1980. It should be based on the current trend of need.

The author feels that using the output value of 2,200,000 tons of soda ash in 1980 as the base for doubling production would perhaps not be far from the actual situation. This means that the soda ash output value will reach 9,000,000 tons by the end of this century. This also means that based on the 1980 actual output value, the output increases at an average rate of 8.85~9 percent a year. At this rate, by the end of this century, soda ash production could be considered 'on the whole' as just meeting the needs for development of the national economy. This also means that by the end of this century, China's average soda ash output per capita will be just 7.3 kg, which is only around 1/4 of the level of more developed industrial countries.

III. Development of the Soda Ash Industry With a Higher Growth Rate Is Possible

As everyone knows, our soda ash industry has more than 60 years of history. China's development of 'Hou's method for the preparation of soda ash' has made a great contribution to the world's soda ash industrial history.

For many years, the soda ash industry has become a strong technical force combining research, design, production and equipment manufacturing, and has accumulated a lot of practical experience, besides, China has plenty of raw materials for soda ash preparation. Therefore, China can develop the production of soda ash at a higher growth rate, which is necessary and possible. China was exporting soda ash some 20 years ago with a good reputation. For various reasons the soda ash industry has been slowed down in recent years and instead of exporting, China is importing larger and larger amounts to compensate for her shortage. The increasing amount of imports are hurting the development of the national economy. Therefore, if China can avoid making mistakes in the regulation of soda ash production, the development of the soda ash industry would be growing at a faster rate. (Paper received in May 1984.)

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NATIONAL DEVELOPMENTS

QINGHUA UNIVERSITY ESTABLISHES S&T CENTER FOR GRADUATE STUDENTS

Beijing GUANGMING RIBAO in Chinese 19 Jul 85 p 2

[Article by reporter Zhou Xiaoping [0719 1420 1627]: "The Applied S&T Service Center of the Graduate School of Qinghua University Builds a Bridge for Its Graduate Students To Participate in Science Practice"]

[Text] The Applied S&T Service Center of the Graduate School of Qinghua University has tentatively initiated S&T service activities for its graduate students. The Applied S&T Service Center has been organized for S&T service under the guidance and with the support of the university and its graduate school. It shows itself externally as an economic entity of its own, and internally it brings the superiority in science and engineering of a comprehensive university fully into play. It assists the more than 1,500 doctoral and master degree research personnel to make positive contributions toward the instruction and scientific research at the university as well as toward the S&T development of society.

Since its initiation in November last year, the Qinghua Applied S&T Service Center has established long-term and comprehensive S&T cooperative relations with Nanyang City in Henan, Yancheng City in Jiangsu and Huairo and Pinggu in the Beijing Municipality. The center has served as consultant on various matters to several hundred units and responded to more than 50 requests for technical service, cordially welcomed by all of society. A leader in one of the units said most gratefully: "Every year only a few students in our line are allotted to these places here. If graduate students would use vacation time every year to come here and give technological guidance, serve as probationary factory directors and engineers, it would mean that we could count on a number of graduate students every year."

With the rising level of S&T in China, the trial-production of every new product is frequently the result of mutual collaboration among several disciplines. The center is paying attention to increasing the mutual osmosis between the various disciplines. Through the organization of cooperation across S&T specializations, it was possible to develop a cylinder stroke control device for a computer for the metal forging research group of the university. This is of major significance, showing the way that new technologies can be used in traditional specializations. The center also provides an excellent locale for graduate students from all specializations of

the university to engage in extended interdisciplinary scholarly exchanges. The scope of requests from outside, which the center entertains, comprises all specializations represented in Qinghua University. The members of the center, each specializing in a certain field, are on their own initiative trying to learn the basic knowledge of all the other specializations and their developmental conditions. Graduate students who in their own research meet with difficulties that extend beyond their fields of specialization can easily find someone in the center to render them assistance. Most recently, the center initiated the organization of graduate students from three departments and four specializations to jointly complete a very important research project.

The center has also been entrusted by the Graduate School of Qinghua University to arrange a part of the practical training required within the training program for graduate students through its organization of S&T service activities, thus rendering the Qinghua Applied S&T Service Center into a bridge that enables the graduate students to come in contact with society, whereby the graduate students not only consolidate their acquired knowledge in actual practice, but also learn things that are not taught in classrooms and laboratories. At the same time, many students, in the course of this part-work and part-study system, rendering S&T services against remuneration, work toward maintaining themselves by their own labor. Presently, the Qinghua Applied S&T Service Center has attained economic independence, and the students taking part in the S&T services are also able to gain certain economic benefits from it.

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VECTOR VALUED LONG JAMES TYPE BANACH SPACES $J(\eta, \ell_p)$ $(1 \leqslant p < +\infty)$

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[Text] The concept of the transfinite basis of a Banach space is introduced in [3]. In this paper we investigate the vector valued long James type Banach spaces. We find that $J(\eta, l_p)$ $(1 < p < \infty)$ and its dual $J(\eta, l_p)^*$ have the transfinite bases, and if a Banach space X has a transfinite basis, so does the space $J(\eta, X)$.

We will use the following definitions for transfinite series and basis in a Banach space X. Let η be an ordinal number, and let $x_\alpha \in X$ be given for each $\alpha < \eta$. The value (when it exists) of the series

$$\sum_{\alpha<\tau} x_\alpha$$

is defined recursively as follows. If $\tau = 0$, then

$$\sum_{\alpha<0} x_\alpha = 0.$$

If $\tau = \beta + 1$ is a successor, then

$$\sum_{\alpha<\tau} x_\alpha = \sum_{\alpha<\beta} x_\alpha + x_\beta,$$

provided the series on the right-hand side converges. If τ is a limit, then

$$\sum_{\alpha<\tau} x_\alpha = \lim_{\beta<\tau} \left(\sum_{\alpha<\beta} x_\alpha \right),$$

where the limit is taken in the norm topology of X.

A transfinite sequence $(x_\alpha)_{\alpha<\eta}$ of vectors is called a basis for X if and only if for each $y \in Y$, there is a unique sequence $(C_\alpha)_{\alpha<\eta}$ of scalars such that

$$y = \sum_{\alpha<\eta} C_\alpha x_\alpha.$$

Suppose η is an ordinal number. $[0, \eta]$ is a set of ordinal numbers with the order topology. The Banach space l_2 consists of the sequences $a = (a_0, a_1, a_2, \cdots, a_n, \cdots)$ with the norm $\|a\| = \left(\sum_{n=0}^{\infty} a_n^2 \right)^{1/2} < \infty$. In particular, the unit vectors in the space l_2 are defined

by $e_0 = (1, 0, 0, \cdots, 0, \cdots)$, $e_1 = (0, 1, 0, \cdots, 0, \cdots)$, $e_2 = (0, 0, 1, 0, \cdots, 0, \cdots)\cdots$, $e_n = (0, 0, \cdots, 0, 1, 0, \cdots)$, $\cdots$. The vector e_n in l_2 is the vector that has 1 in its $(n+1)$ th slot and zeros elsewhere. The vector valued long James type Banach space $J(\eta, l_2)$ consists of the vector valued functions F defined on $[0, \eta]$ and values in l_2 which satisfy the following conditions:

(i) $F(0) = 0$;

(ii) $\|F\| = \sup \left(\sum_{i=1}^{n} \|F(\alpha_i) - F(\alpha_{i-1})\|_{l_2}^2 \right)^{1/2}$,

where the sup is taken over all finite sequences $\alpha_0 < \alpha_1 < \cdots < \alpha_n$ in $[0, \eta]$;

(iii) F is continuous in the norm $\|\cdot\|_{l_2}$.

It is easy to see that $(J(\eta, l_2), \| \|)$ is a Banach space. The norm $\|\!| \cdot |\!\|$ defined by

$$|\!|\!| F |\!|\!| = \sup \left(\sum_{i=1}^{k} \|F(\beta_{2i-1}) - F(\beta_{2i})\|_{l_2}^2 + \|F(\beta_{2k})\|_{l_2}^2 \right)^{1/2} \tag{1}$$

is equivalent to the norm $\| \|$, where the sup is taken over all finite sequences:

$$\beta_1 < \beta_2 < \cdots < \beta_{2i-1} < \beta_{2i} < \cdots < \beta_{2k-1} < \beta_{2k} \text{ in } [0, \eta]$$

We call the space $J(\eta, l_2)$ the l_2-valued long James type Banach space.

Let us now consider functions $(\phi_{\alpha,i})$ defined by

$$\phi_{\alpha,i}(r) = \begin{cases} e_i, & \text{if } r \in (\alpha, \eta], \\ 0, & \text{if } r \notin (\alpha, \eta], \end{cases} \tag{2}$$

where $\alpha \in [0, \eta]$, $r \in [0, \eta]$, $i \in [0, \omega)$, $e_i = (0, 0, \cdots, 0, 1, 0, 0, \cdots) \in l_2$ and ω is the first infinite ordinal number.

We know that $\phi_{\alpha,i} \in J(\eta, l_2)$ and $\|\phi_{\alpha,i}\| = 1$ for any $\alpha \in [0, \eta]$ and for any $i \in [0, \omega)$.

Suppose $F \in J(\eta, l_2)$, $F = (F(\alpha))\alpha \in [0, \eta]$, where

$$F(\alpha) = (F_{\alpha,1}, F_{\alpha,2}, \cdots, F_{\alpha,i}, \cdots) \in l_2.$$

Theorem 1. *$((\phi_{\alpha,i})_{i \in [0,\omega)})_{\alpha \in [0,\eta)}$ is a transfinite basis of the Banach space $J(\eta, l_2)$. Furthermore, for any $F \in J(\eta, l_2)$ we have*

$$F = \sum_{\alpha \in [0,\eta)} \sum_{i \in [0,\omega)} C_{\alpha,i} \phi_{\alpha,i} \tag{3}$$

where $C_{\alpha,i} = F_{\alpha+1,i} - F_{\alpha,i}$.

Proof. Let us consider a projection P_α from $J(\eta, l_2)$ into $J(\eta, l_2)$ defined by

$$P_\alpha F = F\chi_{[0,\alpha]} + F(\alpha)\chi_{(\alpha,\eta]}$$

where $\chi_{[0,\alpha]}$ and $\chi_{(\alpha,\eta]}$ are the characteristic functions of $[0, \alpha]$ and $(\alpha, \eta]$ respectively, $\alpha \in [0, \eta]$. In particular $P_\eta F = F$.

Using the same argument as in Proposition 1 of [3] we see that

$$\|P_\alpha F - P_\beta F\| \to 0 \text{ as } \alpha \to \beta,$$

if β is a limit point in $[0, \eta]$. Therefore $\lim_{\alpha \to \eta} P_\alpha F = F$ in norm in the Banach space $J(n, l_2)$.

For any $\alpha \in [0, \eta)$, the series $\sum_{i \in [0,\omega)} C_{\alpha,i}\phi_{\alpha,i}$ converges. In fact, for any $\varepsilon > 0$, there exists an integer $N > 0$ such that

$$\sum_{i=N+1}^{N+M} F_{\alpha+1,i}^2 < \left(\frac{\varepsilon}{2}\right)^2, \quad \sum_{i=N+1}^{N+M} F_{\alpha,i}^2 < \left(\frac{\varepsilon}{2}\right)^2$$

for any integer $M > 0$. Since

$$\begin{aligned} \| \sum_{i=N+1}^{N+M} C_{\alpha,i}\phi_{\alpha,i} \|^2 &= \sum_{i=N+1}^{N+M} (F_{\alpha+1,i} - F_{\alpha,i})^2 \\ &\leqslant \sum_{i=N+1}^{N+M} F_{\alpha+1,i}^2 + \sum_{i=N+1}^{N+M} F_{\alpha,i}^2 \\ &\quad + 2\left(\sum_{i=N+1}^{N+M} F_{\alpha+1,i}^2\right)^{1/2}\left(\sum_{i=N+1}^{N+M} F_{\alpha,i}^2\right)^{1/2}, \end{aligned}$$

it follows that $\| \sum_{i=N+1}^{N+M} C_{\alpha,i}\phi_{\alpha,i} \| < \varepsilon$, for any $M > 0$.

We now only need to show that

$$P_\tau F = \sum_{\alpha \in [0,\tau)} \sum_{i \in [0,\omega)} C_{\alpha,i}\phi_{\alpha,i}.$$

This is true for $\tau = 0$. Suppose it is true for τ, i. e.,

$$\begin{aligned} P_\tau F &= F_{\chi_{[0,\tau]}} + F(\alpha)_{\chi_{(\tau,\eta]}} \\ &= \sum_{\alpha \in [0,\tau)} \sum_{i \in [0,\omega)} C_{\alpha,i}\phi_{\alpha,i}. \end{aligned}$$

By the definition of P_τ,

$$\begin{aligned} P_{\tau+1}F &= F_{\chi_{[0,\tau+1]}} + F(\tau+1)_{\chi_{(\tau+1,\eta]}} \\ &= F_{\chi_{[0,\tau]}} + F(\tau+1)_{\chi_{(\tau,\tau+1]}} + F(\tau+1)_{\chi_{(\tau+1,\eta]}} \\ &= F_{\chi_{[0,\tau]}} + F(\tau)_{\chi_{(\tau,\eta]}} + F(\tau+1)_{\chi_{(\tau,\eta]}} - F(\tau)_{\chi_{(\tau,\eta]}} \\ &= P_\tau F + (F(\tau+1) - F(\tau))_{\chi_{(\tau,\eta]}} \\ &= \sum_{\alpha \in [0,\tau)} \sum_{i \in [0,\omega)} C_{\alpha,i}\phi_{\alpha,i} + \sum_{i \in [0,\omega)} C_{\tau,i}\phi_{\tau,i} \\ &= \sum_{\alpha \in [0,\tau+1)} \sum_{i \in [0,\omega)} C_{\alpha,i}\phi_{\alpha,i}. \end{aligned}$$

If τ is a limit ordinal, then

$$\sum_{\alpha \in [0,\tau)} \sum_{i \in [0,\omega)} C_{\alpha,i}\phi_{\alpha,i} = \lim_{\beta < \tau} \left(\sum_{\alpha < \beta} \sum_{i \in [0,\omega)} C_{\alpha,i}\phi_{\alpha,i_1} \right)$$

$$= \lim_{\beta<\tau} (P_\beta F) = P_\tau F \text{ in norm.}$$

Therefore

$$P_\tau F = \sum_{\alpha\in[0,\tau)} \sum_{i\in[0,\omega)} C_{\alpha,i}\phi_{\alpha,i}.$$

This completes the proof.

Remark 2. The transfinite basis of $J(\eta, l_2)$ is

$$\{\phi_{0,0}, \phi_{0,1}, \phi_{0,2}, \cdots, \phi_{1,0}, \phi_{1,1}, \phi_{1,2}, \cdots, \phi_{\omega,0}, \phi_{\omega,1}, \phi_{\omega,2}, \cdots,$$
$$\phi_{\omega,0}, \phi_{\omega,1}, \phi_{\omega,2}, \cdots, \phi_{\omega+1,0}, \phi_{\omega+1,1}, \phi_{\omega+1,2}, \cdots\}.$$

The order type of this transfinite basis is $\omega \cdot \eta$. There is one to one correspondence between the two:

$$(\alpha, i) \longleftrightarrow \delta = \omega\alpha + i,$$
$$i \in [0, \omega), \qquad \delta \in [0, \omega \cdot \eta),$$
$$\alpha \in [0, \eta).$$

In the l_p valued long James type Banach space $J(\eta, l_p)$ $(1 \leqslant p < \infty)$ we have

Theorem 3. *$((\phi_{\alpha,i})_{i\in[0,\omega)})_{\alpha\in[0,\eta)}$ is a transfinite basis of the l_p valued long James type Banach space $J(\eta, l_p)$ $(1 \leqslant p < \infty)$ and for any $F \in J(\eta, l_p)$*

$$F = \sum_{\alpha\in[0,\eta)} \sum_{i\in[0,\omega)} C_{\alpha,i}\phi_{\alpha,i}$$

where

$$C_{\alpha,i} = F_{\alpha+1,i} - F_{\alpha,i},$$

$$\phi_{\alpha,i}(\tau) = \begin{cases} e_i, & \text{if } \tau \in (\alpha, \eta], \\ 0, & \text{if } \tau \notin (\alpha, \eta], \end{cases}$$

e_i being a unit vector in l_p that has 1 in its $(i+1)$ th slot and zeros elsewhere.

Proof. We only need to notice that

$$\sum_{i\in[0,\omega)} F_{\alpha+1,i}\phi_{\alpha,i}(\tau) = \begin{cases} \sum_{i\in[0,\omega)} F_{\alpha+1,i}\, e_i, & \text{if } \tau \in (\alpha+1, \eta], \\ 0, & \text{if } \tau \notin (\alpha+1, \eta], \end{cases}$$

and

$$\sum_{i\in[0,\omega)} F_{\alpha,i}\phi_{\alpha,i}(\tau) = \begin{cases} \sum_{i\in[0,\omega)} F_{\alpha,i}\, e_i, & \text{if } \tau \in (\alpha, \eta], \\ 0, & \text{if } \tau \notin (\alpha, \eta]. \end{cases}$$

Then

$$\sum_{i\in[0,\omega)} (F_{\alpha+1,i} - F_{\alpha,i})\phi_{\alpha,i}(\tau)$$

$$= \begin{cases} \sum\limits_{i\in[0,\omega)} F_{\alpha+1,i}\ e_i - \sum\limits_{i\in[0,\omega)} F_{\alpha i}\ e_i, & \text{if } r\in(\alpha+1,\eta], \\ \sum\limits_{i\in[0,\omega)} F_{\alpha i}\ e_i, & \text{if } r\in(\alpha,\alpha+1], \\ 0, & \text{if } r\in[0,\alpha]. \end{cases}$$

The series

$$\sum_{i\in[0,\omega)} F_{\alpha+1,i}\ e_i - \sum_{i\in[0,\eta)} F_{\alpha i}\ e_i, \sum_{i\in[0,\omega)} F_{\alpha i}\ e_i$$

are convergent in l_p norm. So for any $\alpha\in[0,\eta)$, the series $\sum\limits_{i\in[0,\omega)} C_{\alpha i}\phi_{\alpha i}$ is convergent in norm.

The rest of the proof is similar to that of Theorem 1.

More generally, suppose X is a Banach space. Similarly we can define a Banach space $J(\eta, X)$ consisting of the functions F on $[0,\eta]$ and values in X which satisfy the following conditions:

(i) $F(0)=0$;

(ii) $\|F\| = \sup\left(\sum\limits_{i=1} \|F(\alpha_i) - F(\alpha_i - 1)\|_X^2\right)^{1/2} < +\infty$,

where the sup is taken over all finite sequences $\alpha_0 < \alpha_1 < \cdots < \alpha_n$ in $[0,\eta]$;

(iii) F is X-norm continuous on $[0,\eta]$.

We call this space $J(\eta, X)$ the X valued long James type Banach space.

Theorem 4. *Suppose X is a Banach space with a Schauder basis $\{x_i\}_{i=0}^{\infty}$, and*

$$\phi_{\alpha i}(r) = \begin{cases} x_i, & \text{if } r\in(\alpha,\eta], \\ 0, & \text{if } r\notin(\alpha,\eta], \end{cases}$$

where $i\in[0,\omega)$, $\alpha\in[0,\eta)$. Then $((\phi_{\alpha i})_{i\in[0,\omega)})_{\alpha\in[0,\eta)}$ is a transfinite basis of the X valued long James type Banach space $J(\eta, X)$ and for any $F\in J(\eta,X)$ we have

$$F = \sum_{\alpha\in[0,\eta)} \sum_{i\in[0,\omega)} C_{\alpha i}\phi_{\alpha i},$$

where

$$C_{\alpha i}(F) = F_{\alpha+1,i} - F_{\alpha i}.$$

This theorem can be proved using the same method as in Theorem 3.

Let us consider the associated transfinite sequence of coefficient functionals $((C_{\alpha i})_{i\in[0,\omega)})_{\alpha\in[0,\eta)}$ defined in Theorem 1. $((C_{\alpha i}, \phi_{\alpha i})_{i\in[0,\omega)})_{\alpha\in[0,\eta)}$ is a transfinite biorthogonal system.

Theorem 5. *The biorthogonal functionals $((C_{\alpha i})_{i\in[0,\omega)})_{\alpha\in[0,\eta)}$ associated with $((\phi_{\alpha i})_{i\in[0,\omega)})_{\alpha\in[0,\eta)}$ which is a transfinite basis of the Banach space $J(\eta, l_2)$ form a transfinite basis of the dual space $J(\eta, l_2)^*$, and we have the representation:*

$$l = \sum_{\alpha \in [0,\eta)} \sum_{i \in [0,\omega)} l(\phi_{\alpha i}) C_{\alpha i} \tag{4}$$

for any $l \in J(\eta, l_2)^*$.

Proof. Since $((\phi_{\alpha i})_{i \in [0,\omega)})_{\alpha \in [0,\eta)}$ is a biorthogonal system, for any $l \in J(\eta, l_2)^*$ we have

$$l = \sum_{\alpha \in [0,\eta)} \sum_{i \in [0,\omega)} l(\phi_{\alpha i}) C_{\alpha i}$$

in the W^*-topology in the Banach space $J(\eta, l_2)^*$ (see p. 8 in [5]). We now need to show that the transfinite series

$$\sum_{\alpha \in [0,\eta)} \sum_{i \in [0,\omega)} l(\phi_{\alpha i}) C_{\alpha i}$$

converges to l in norm in the Banach space $J(\eta, l_2)^*$.

(i) We will show that for any fixed $\alpha \in [0, \eta)$ the series

$$\sum_{i \in [0,\omega)} l(\phi_{\alpha i}) C_{\alpha i}$$

is convergent to l in the Banach space $J(\eta, l_2)^*$, for any $l \in J(\eta, l_2)^*$.

Suppose not. Then there exist $\varepsilon > 0$ and integers $i_1 < i_2 < \cdots i_n < \cdots \to \infty (n \to \infty)$ such that

$$\| \sum_{i \in [i_n, i_{n+1})} l(\phi_{\alpha i}) C_{\alpha i} \| > \varepsilon.$$

Choose

$$\phi_n \in J(\eta, l_2), \ \|\phi_n\| \leqslant 1 \text{ and } \phi_n = \sum_{\alpha \in [0,\eta)} \sum_{i \in [0,\omega)} C_{\alpha i}(\phi_n) \phi_{\alpha i}$$

such that

$$\left\langle \sum_{i \in [i_n, i_{n+1})} l(\phi_{\alpha i}) C_{\alpha i}, \phi_n \right\rangle > \varepsilon.$$

By the biorthogonality we can choose

$$f_n = \sum_{i \in [i_n, i_{n+1})} C_{\alpha i}(\phi_n) \phi_{\alpha i}$$

such that $\|f_n\| \leqslant \|\phi_n\| \leqslant 1$ and

$$\left\langle \sum_{i \in [i_n, i_{n+1})} l(\phi_{\alpha i}) C_{\alpha i}, f_n \right\rangle$$
$$= \left\langle \sum_{i \in [i_n, i_{n+1})} l(\phi_{\alpha i}) C_{\alpha i}, \phi_n \right\rangle > \varepsilon$$

Since

$$\langle l, f_n \rangle = \left\langle \sum_{i \in [i_n, i_{n+1})} l(\phi_{\alpha i}) C_{\alpha i}, f_n \right\rangle,$$

so $\langle l, f_n \rangle > \varepsilon$, for any $n \in [0, \omega)$. Let

$$f = \sum_{n=1}^{\infty} f_n/n.$$

We now prove that $f \in J(\eta, l_2)$. Suppose

$$\beta_1 < \beta_2 < \cdots < \beta_{2i-1} < \beta_{2i} < \cdots < \beta_{2k-1} < \beta_{2k}$$

is a partition of $[0, \eta]$. There are three cases:

(a) The partition points, say β_{2i-1}, β_{2i} of the term $\|f(\beta_{2i-1}) - f(\beta_{2i})\|^2$ in (1), are greater than α, i. e.

$$\alpha < \beta_{2i-1} < \beta_{2i}.$$

(b) The partition points, say β_{2j-1}, β_{2j} of the term $\|f(\beta_{2j-1}) - f(\beta_{2j})\|^2$ in (1), are less than or equal to α, i. e.

$$\beta_{2j-1} < \beta_{2j} < \alpha.$$

(c) The partition points β_{2m-1}, β_{2m} of the term $\|f(\beta_{2m-1}) - f(\beta_{2m})\|^2$ satisfy

$$\beta_{2m-1} \leqslant \alpha \leqslant \beta_{2m}.$$

The sum of the terms in case (a) and case (b) appearing in (1) is equal to zero. By the definition of the equivalent norm (1),

$$\begin{aligned}
\|f\|^2 &= \sum_{\text{case } a} \|f(\beta_{2i-1}) - f(\beta_{2i})\|_{l_2}^2 + \sum_{\text{case } b} \|f(\beta_{2j-1}) - f(\beta_{2j})\|_{l_2}^2 \\
&\quad + \|f(\beta_{2m-1}) - f(\beta_{2m})\|_{l_2}^2 + \|f(\beta_{2k})\|_{l_2}^2 \\
&\qquad \text{case } c \\
&= \|f(\beta_{2m-1}) - f(\beta_{2m})\|_{l_2}^2 + \|f(\beta_{2k})\|_{l_2}^2 \\
&= \|f(\beta_{2m})\|_{l_2}^2 + \|f(\beta_{2k})\|_{l_2}^2 \\
&= \Big\| \sum_{n \in [1,\omega)} \frac{1}{n} f_n(\beta_{2m}) \Big\|_{l_2}^2 + \Big\| \sum_{n \in [1,\omega)} \frac{1}{n} f_n(\beta_{2k}) \Big\|_{l_2}^2 \\
&= \sum_{n \in [1,\omega)} \frac{1}{n^2} \|f_n(\beta_{2m})\|_{l_2}^2 + \sum_{n \in [1,\omega)} \frac{1}{n^2} \|f_n(\beta_{2k})\|_{l_2}^2
\end{aligned}$$

(since $\{f_n\}$ have disjoint supports)

$$\begin{aligned}
&\leqslant \sum_{n \in [1,\omega)} \frac{1}{n^2} + \sum_{n \in [1,\omega)} \frac{1}{n^2} \\
&= 2 \sum_{n \in [1,\omega)} \frac{1}{n^2} < \infty.
\end{aligned}$$

So $f \in J(\eta, l_2)$. But $\langle l, f \rangle > \varepsilon \sum_{n \in [1,\omega)} \frac{1}{n}$, i. e. $\|l\| = \infty$, a contradiction.

(ii) We will show that for any $l \in J(\eta, l_2)^*$ and for any limit ordinal $\beta \in [0, \eta]$ the transfinite series

$$\sum_{\alpha \in [0,\beta)} \sum_{i \in [0,\omega)} l(\phi_{\alpha,i}) C_{\alpha,i}$$

converges in norm in the space $J(\eta, l_2)^*$.

Suppose not. Then there are $\varepsilon > 0$, $r_1 < r_2 < \cdots < r_n < \cdots \in [0, \beta)$ and $r_n \to \beta (n \to \infty)$ such that

$$\| \sum_{\alpha \in [r_n, r_{n+1})} \sum_{i \in [0, \omega)} l(\phi_{\alpha,i}) C_{\alpha,i} \| > \varepsilon.$$

So there exists $\phi_n \in J(\eta, l_2)$, $\|\phi_n\| \leqslant 1$ and

$$\phi_n = \sum_{\alpha \in [0, \eta)} \sum_{i \in [0, \omega)} C_{\alpha,i}(\phi_n) \phi_{\alpha,i}$$

such that

$$\left\langle \sum_{\alpha \in [r_n, r_{n+1})} \sum_{i \in [0, \omega)} l(\phi_{\alpha,i}) C_{\alpha,i}, \phi_n \right\rangle > \varepsilon.$$

By the biorthogonality we can get

$$f_n = \sum_{\alpha \in [r_n, r_{n+1})} \sum_{i \in [0, \omega)} C_{\alpha,i}(\phi_n) \phi_{\alpha,i} \text{ and } \|f_n\| \leqslant \|\phi_n\| \leqslant 1$$

such that

$$\left\langle \sum_{\alpha \in [r_n, r_{n+1})} \sum_{i \in [0, \omega)} l(\phi_{\alpha,i}) C_{\alpha,i}, f_n \right\rangle - \left\langle \sum_{\alpha \in [r_n, r_{n+1})} \sum_{i \in [0, \omega)} l(\phi_{\alpha,i}) C_{\alpha,i}, \phi_n \right\rangle > \varepsilon.$$

Notice that

$$\langle l, f_n \rangle = \left\langle \sum_{\alpha \in [r_n, r_{n+1})} \sum_{i \in [0, \omega)} l(\phi_{\alpha,i}) C_{\alpha,i}, f_n \right\rangle.$$

Then

$$\langle l, f_n \rangle > \varepsilon. \text{ Let } f_n(\alpha) = \sum_{i \in [0, \omega)} C_{\alpha,i}(\phi_n) \phi_{\alpha,i}.$$

By the definition of the norm of the space $J(\eta, l_2)$,

$$\|f_n(\alpha)\| \leqslant \|f_n\| \leqslant 1.$$

We now write f_n in the following form:

$$f_n = \sum_{\alpha \in [r_n, r_{n+1})} f_n(\alpha),$$

Let

$$f = \sum_{n=1}^{\infty} \frac{1}{n} f_n = \sum_{n=1}^{\infty} \sum_{\alpha \in [r_n, r_{n+1})} \frac{1}{n} f_n(\alpha).$$

Consider the following two cases:

(a) There exist integers n' and n'' such that the partition points β_{2i-1} and β_{2i} in the term $\|f(\beta_{2i-1}) - f(\beta_{2i})\|_{l_2}^2$ in (1) satisfy

$$r_{n'} \leqslant \beta_{2i-1} < r_{n'+1}, \quad r_{n''} \leqslant \beta_{2i} < r_{n''+1},$$

where $n' \neq n''$. The sum of these terms is less than or equal to

$$\sum_{n=1}^{\infty}\left(\frac{1}{n}+\frac{1}{n+1}\right)^2<4\sum_{n=1}^{\infty}\frac{1}{n^2}.$$

(b) There is an integer n such that the partition points $\beta_{2p-1}<\beta_{2p}<\cdots<\beta_{2q-1}<\beta_{2q}$ of the terms $\|f(\beta_{2p-1})-f(\beta_{2p})\|_{l_1}^2,\cdots,\|f(\beta_{2q-1})-f(\beta_{2q})\|_{l_1}^2$ in (1) are in the set $[r_n, r_{n+1})$. Then

$$\sum_{i=p}^{q}\|f(\beta_{2i-1})-f(\beta_{2i})\|_{l_1}^2=\frac{1}{n^2}\sum_{i=p}^{q}\|f_n(\beta_{2i-1})-f_n(\beta_{2i})\|_{l_1}^2\leqslant\|f_n\|^2/n^2\leqslant\frac{1}{n^2}.$$

Therefore

$$\begin{aligned}&\sum_{i=1}^{k}\|f(\beta_{2i-1})-f(\beta_{2i})\|_{l_1}^2+\|f(\beta_{2k})\|_{l_1}^2\\&\leqslant\sum_{n\in[1,\omega)}\|f_n\|^2/n^2+4\sum_{n\in[1,\omega)}\frac{1}{n^2}+\sum_{n\in[1,\omega)}\frac{1}{n^2}\\&\leqslant 6\sum_{n\in[1,\omega)}\frac{1}{n^2}<+\infty.\end{aligned}$$

So $f\in J(\eta,l_1)$. But

$$\left\langle l,\sum_{n\in[1,\omega)}\frac{1}{n}f_n\right\rangle>s\sum_{n\in[1,\omega)}\frac{1}{n},$$

i. e., $\langle l,f\rangle=\infty$. This contradiction completes the proof.

Theorem 6. *The transfinite sequence of coefficient functionals associated with the transfinite basis $((\phi_{n,i})_{i\in[0,\omega)})_{n\in[0,\eta)}$ of the space $J(\eta,l_p)(1<p<\infty)$ forms a transfinite basis of the dual $J(\eta,l_p)^*(1<p<\infty)$ and for any $l\in J(\eta,l_p)^*$, we have*

$$l=\sum_{n\in[0,\eta)}\sum_{i\in[0,\omega)}l(\phi_{n,i})C_{n,i}.$$

Proof. We only need to notice that using the same method as in part (i) of the proof of Theorem 5 we can get the $\{f_n\}_{n\in[1,\omega)}$ which have disjoint supports. Since

$$\|\sum_{n\in[1,\omega)}f_n\|^p=\sum_{n\in[1,\omega)}\|f_n\|^p(0<p<\infty)$$

we have

$$\begin{aligned}\|f\|^2&=\|f(\beta_{2m})\|_{l_p}^2+\|f(\beta_{2k})\|_{l_p}^2\\&=\|\sum_{n\in[1,\omega)}\frac{1}{n}f_n(\beta_{2m})\|_{l_p}^2+\|\sum_{n\in[1,\omega)}\frac{1}{n}f_n(\beta_{2k})\|_{l_p}^2\\&=\left(\|\sum_{n\in[1,\omega)}\frac{1}{n}f_n(\beta_{2m})\|_{l_p}^p\right)^{2/p}+\left(\|\sum_{n\in[1,\omega)}\frac{1}{n}f_n(\beta_{2k})\|_{l_p}^p\right)^{2/p}\\&=\left(\sum_{n\in[1,\omega)}\frac{1}{n^p}\|f_n(\beta_{2m})\|_{l_p}^p\right)^{2/p}+\left(\sum_{n\in[1,\omega)}\frac{1}{n^p}\|f_n(\beta_{2k})\|_{l_p}^p\right)^{2/p}\\&\leqslant 2\left(\sum_{n\in[1,\omega)}\frac{1}{n^p}\right)^{2/p}<+\infty.\end{aligned}$$

So

$$f \in J(\eta, l_p) \quad (1 < p < +\infty).$$

The proof of the rest of this theorem is the same as the proof of Theorem 5.

G. A. Edgar proves that any Banach space with a transfinite basis has the approximation property (unpublished). Combining this conclusion with our results we have the following corollaries.

Corollary 7. The Banach spaces $J(\eta, l_p)$ $(1 \leqslant p < +\infty)$ and $J(\eta, l_p)^*(1 < p < +\infty)$ have the approximation property for any ordinal number η.

Corollary 8. If a Banach space X has a Schauder basis, then $J(\eta, X)$ has the approximation property for any ordinal number η.

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PHYSICAL SCIENCES

FINITE DIFFERENCE SCHEME FOR ONE-DIMENSIONAL MAGNETOHYDRODYNAMIC EQUATIONS*

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[Text] Abstract

In this paper we present a finite difference scheme for magnetohydrodynamic equations in one dimension. Numeric results have verified its effectiveness

§1. Cylindrically Symmetric One-dimensional Magnetohydrodynamic Equations Assumptions

1. The magnetic permitivity is not significantly different from 1, therefore, $\mu = 1$.

2. The field cycle is much longer than the characteristic collision time of electron, i.e., the electronic collision frequency is much higher than the Larmor frequency ($eH/m_e c$).

3. $(V/c)^2 \ll 1$ (refer to references [1] and [2]), i.e., a nonrelativistic approximation.

The general equations in a medium are

$$\nabla \cdot \boldsymbol{B} = 0, \tag{1.1}$$

$$\frac{\partial \boldsymbol{B}}{\partial t} = \nabla \times (\boldsymbol{V} \times \boldsymbol{B}) - \frac{c^2}{4\pi} \nabla \times \left(\frac{1}{\sigma} \nabla \times \boldsymbol{B} \right), \tag{1.2}$$

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{V}) = 0, \tag{1.3}$$

$$\frac{\partial \boldsymbol{V}}{\partial t} + (\boldsymbol{V} \cdot \nabla) \boldsymbol{V} = -\frac{\nabla p}{\rho} - \frac{1}{4\pi\rho} (\boldsymbol{B} \times \nabla \times \boldsymbol{B}), \tag{1.4}$$

$$p = p(\rho, \varepsilon), \tag{1.5}$$

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$$\frac{\partial}{\partial t}\left(\frac{\rho V^2}{2}+\rho\varepsilon+\frac{B^2}{8\pi}\right)=-\nabla\cdot\boldsymbol{q}, \tag{1.6}$$

$$\boldsymbol{q}=\rho\boldsymbol{V}\left(\frac{V^2}{2}+\varepsilon+\frac{p}{\rho}\right)+\frac{1}{4\pi}(\boldsymbol{B}\times(\boldsymbol{V}\times B))$$

$$-\frac{c^2}{16\pi^2\sigma}\boldsymbol{B}\times(\nabla\times\boldsymbol{B})-K\nabla T, \tag{1.7}$$

where **B** is the magnetic induction intensity, t is time, **V** is velocity of the fluid, c is speed of light, σ is electrical conductivity, p is pressure of the material, ρ is density, ε is internal energy per unit mass, T is temperature and K is the thermal conductivity coefficient.

The following one-dimensional magnetohydrodynamic equations can be derived from the above equations using thermodynamic relations.

1. Equations in Euler Coordinates

(1) By neglecting thermal conduction, together with **V** = (u(R,t),0,0) and **B** = (0,0,B_Z(R,t)) (i.e., the magnetic field is in the axial direction of the cylinder), we get

$$\frac{\partial B_z}{\partial t}=-\frac{1}{R}\frac{\partial}{\partial R}(RuB_z)+\frac{1}{R}\frac{\partial}{\partial R}\left(\nu_m R\frac{\partial B_z}{\partial R}\right), \tag{1.8}$$

$$\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial R}\right)\rho=-\frac{\rho}{R}\frac{\partial}{\partial R}(Ru), \tag{1.9}$$

$$\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial R}\right)u=-\frac{1}{\rho}\frac{\partial p}{\partial R}-\frac{1}{4\pi\rho}B_z\frac{\partial B_z}{\partial R}$$

$$=-\frac{1}{\rho}\frac{\partial}{\partial R}\left(p+\frac{B_z^2}{8\pi}\right), \tag{1.10}$$

$$\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial R}\right)\varepsilon=-p\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial R}\right)\left(\frac{1}{\rho}\right)+\frac{c^2}{16\pi^2\sigma\rho}\left(\frac{\partial B_z}{\partial R}\right)^2, \tag{1.11}$$

$$p=p(\rho,\varepsilon). \tag{1.12}$$

(2) For **V** = (u(R,t),0,0) and **B** = (0,B_φ(R,t),0) (i.e., the magnetic field is tangent to the cylinder), we have

$$\frac{\partial B_\varphi}{\partial t}=-\frac{\partial}{\partial R}(uB_\varphi)+\frac{\partial}{\partial R}\left(\frac{\nu_m}{R}\frac{\partial}{\partial R}(RB_\varphi)\right), \tag{1.13}$$

$$\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial R}\right)\rho=-\frac{\rho}{R}\frac{\partial}{\partial R}(Ru), \tag{1.14}$$

$$\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial R}\right)u=-\frac{1}{\rho}\frac{\partial p}{\partial R}-\frac{1}{4\pi\rho}\frac{B_\varphi}{R}\frac{\partial(RB_\varphi)}{\partial R}$$

$$=-\frac{1}{\rho}\frac{\partial}{\partial R}\left(p+\frac{B_\varphi^2}{8\pi}\right)-\frac{B_\varphi^2}{4\pi\rho R}, \tag{1.15}$$

$$\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial R}\right)\varepsilon=-p\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial R}\right)\left(\frac{1}{\rho}\right)$$
$$+\frac{c^2}{16\pi^2\sigma\rho}\left(\frac{1}{R}\frac{\partial(RB_\varphi)}{\partial R}\right)^2, \tag{1.16}$$
$$p=p(\rho,\varepsilon). \tag{1.17}$$

(3) Boundary Conditions

Assuming the fluid is not a superconductor, i.e., its electrical conductivity is finite, it is possible to deduce that the magnetic induction intensity B is continuous. From a continuous flow, it is possible to derive that $\nu_m\frac{\partial B_z}{\partial R}$ and $\frac{\nu_m}{R}\frac{\partial(B_\varphi R)}{\partial R}$ are continuous by assuming $B_Z \neq 0$ and $B_\varphi \neq 0$.

From the continuity of momentum, it is possible to derive that $p+\frac{B_\varphi^2}{8\pi}$ and $p+\frac{B_z^2}{8\pi}$ are continuous.

(4) Equations in Vacuum (Cavity Equations)

A cavity exists in the computation model which assumes its inner boundary to be $R_<$ and outer boundary $R_>$. Then, the following equation regarding the magnetic induction intensity **B** can be derived.

1) $\mathbf{B} = (0,0,B_Z)$

$$\frac{d}{dt}\left(B_z\frac{R_>^2-R_<^2}{2}\right)=R\nu_m\frac{\partial B_z}{\partial R}\Big|_{R<}^{R>}. \tag{1.18}$$

2) $\mathbf{B} = (0,B_\varphi,0)$

$$\frac{d}{dt}\left(RB_\varphi\ln\left(\frac{R_>}{R_<}\right)\right)=\frac{\nu_m}{R}\frac{\partial(RB_\varphi)}{\partial R}\Big|_{R<}^{R>}. \tag{1.19}$$

2. Equations, Boundary Conditions and Initial Conditions in Laplace Coordinates

We transformed these equations to the familiar Laplace coordinates because the boundary between materials is clearer and the accuracy of numerical calculation is higher in those coordinates.

(1) The set of equations corresponding to $\mathbf{B} = (0,0,B(r,t))$, where $B(r,t)= B_Z(r,t)$ and r is the Laplace coordinate, is

$$
(1.A)\quad
\begin{cases}
\dfrac{\partial u}{\partial t} = -\dfrac{1}{\rho}\dfrac{\partial}{\partial R}\left(p+q+\dfrac{B^2}{8\pi}\right), \\
\dfrac{\partial R}{\partial t} = u, \\
\rho = \dfrac{\rho_0 r}{R}\dfrac{\partial r}{\partial R}, \\
q = \dfrac{\rho}{2}(a\Delta r)^2\dfrac{\partial u}{\partial r}\left(\dfrac{\partial u}{\partial r}-\left|\dfrac{\partial u}{\partial r}\right|\right), \quad a \text{ is a constant}, \\
\dfrac{\partial \varepsilon}{\partial t}+(p+q)\dfrac{\partial}{\partial t}\left(\dfrac{1}{\rho}\right) = \dfrac{\nu_m}{4\pi\rho}\left(\dfrac{\partial B}{\partial R}\right)^2, \\
p = p(\rho,\varepsilon), \\
\dfrac{\partial B}{\partial t} = \dfrac{1}{R}\left(\dfrac{\partial}{\partial R}\left(R\nu_m\dfrac{\partial B}{\partial R}\right)-\dfrac{B}{R}\dfrac{\partial}{\partial R}(Ru)\right) \\
\left(\text{or } \dfrac{\partial}{\partial t}\left(\dfrac{B}{\rho}\right) = \dfrac{1}{\rho R}\dfrac{\partial}{\partial R}\left(\nu_m R\dfrac{\partial B}{\partial R}\right)\right), \text{ in a medium}, \\
\dfrac{\partial}{\partial t}(B(R_>^2-R_<^2)/2) = R_>\nu_{m>}\left.\dfrac{\partial B}{\partial R}\right|_{R>} \\
\qquad\qquad -R_<\nu_{m<}\left.\dfrac{\partial B}{\partial R}\right|_{R<}, \text{ in the cavity}.
\end{cases}
$$

Here, we introduced Von Neumann's artificial viscosity q (see reference [3]) in order to solve the shockwave interruption problem in computation.

(2) Equations corresponding to B = (0,B(r,t),0)

Here, equations corresponding to $B(r,t) = B_\varphi(r,t)$ are

$$
(1.B)\quad
\begin{cases}
\dfrac{\partial u}{\partial t} = -\dfrac{1}{\rho}\dfrac{\partial}{\partial R}\left(p+q+\dfrac{B^2}{8\pi}\right)-\dfrac{B^2}{4\pi R\rho}, & (1.B.1) \\
\dfrac{\partial R}{\partial t} = u, & (1.B.2) \\
\rho = \dfrac{\rho_0 r}{R}\dfrac{\partial r}{\partial R}, & (1.B.3) \\
q = \dfrac{\rho}{2}(a\Delta r)^2\dfrac{\partial u}{\partial r}\left(\dfrac{\partial u}{\partial r}-\left|\dfrac{\partial u}{\partial r}\right|\right), & (1.B.4) \\
\dfrac{\partial \varepsilon}{\partial t}+(p+q)\dfrac{\partial}{\partial t}\left(\dfrac{1}{\rho}\right) = \dfrac{\nu_m}{4\pi\rho}\left(\dfrac{1}{R}\dfrac{\partial(RB)}{\partial R}\right)^2, & (1.B.5) \\
p = p(\rho,\varepsilon), & (1.B.6) \\
\dfrac{\partial B}{\partial t} = \dfrac{\partial}{\partial R}\left(\dfrac{\nu_m}{R}\dfrac{\partial}{\partial R}(RB)\right)-B\dfrac{\partial u}{\partial R}, & (1.B.7)
\end{cases}
$$

$$\begin{cases} \left(\text{or } \frac{\partial}{\partial t}\left(B\frac{\partial R}{\partial r}\right) = \frac{\partial}{\partial r}\left(\frac{\nu_m}{R}\frac{\partial}{\partial R}(RB)\right)\right), \text{ in a medium,} \\ \frac{\partial}{\partial t}\left(BR\ln\left(\frac{R_>}{R_<}\right)\right) = \frac{\nu_{m>}}{R_>}\frac{\partial(RB)}{\partial R}\Big|_{R>} \\ \qquad\qquad - \frac{\nu_{m<}}{R_<}\frac{\partial(RB)}{\partial R}\Big|_{R<}, \text{ in the cavity.} \end{cases}$$

(3) Boundary and interfacial conditions

$$\text{(1.C)} \begin{cases} u(0,t) = 0, \\ u(r_j - 0, t) = u(r_j + 0, t), \\ p(r_j - 0, t) = p(r_j + 0, t), \\ p(r_{\text{side}}, t) = 0, \ r_{\text{side}} \text{ is the external boundary.} \\ B(r_{JB}, t) = 0, \\ B(r_j - 0, t) = B(r_j + 0, t), \\ \left.\begin{aligned} &\nu_m \frac{\partial B}{\partial R}\Big|_{r_j-0} = \nu_m \frac{\partial B}{\partial R}\Big|_{r_j+0} \\ &\frac{\partial B}{\partial R}\Big|_{r=0} = 0 \end{aligned}\right\} \text{for } B = B_z \\ \left.\begin{aligned} &\frac{\nu_m}{R}\frac{\partial(RB)}{\partial R}\Big|_{r_j-0} = \frac{\nu_m}{R}\frac{\partial(RB)}{\partial R}\Big|_{r_j+0} \\ &B|_{r=0} = 0 \end{aligned}\right\} \text{for } B = B_\varphi \\ (p+q)|_{r=r_{\text{side}}} = 0. \end{cases}$$

(4) Initial conditions

$$\text{(1.D)} \begin{cases} u(r,0) = 0, \\ R(r,0) = R^0(r), \\ \rho(r,0) = \rho_0(r), \\ \varepsilon(r,0) = \varepsilon^0(r), \\ B(r,0) = B^0(r). \end{cases}$$

In computation, we often choose $B(r,t)=0$ in a region $r_{JB} \leqslant r \leqslant r_{\text{boundary}}$ where r_{JB} is a given interface.

§2.Difference Scheme

This is a series of nonlinear partial differential equations and its difference scheme must be established by taking the stability of the scheme into consideration. The difference scheme was established based on the discussion of stability of linear problems as well as on the calculation of nonlinear problems and the stability of individual equations in specific conditions. Physical

continuity was taken into account in the treatment. The scheme has been proven to be valid in the computation of various complicated models.

1. Difference Scheme for B = (0,B(r),0)

(1) Difference scheme for (1.B.1)

Let us divide time into $t^n(n=0,1\cdots)$, then

$$\Delta t^n = t^{n+\frac{1}{2}} - t^{n-\frac{1}{2}} = \frac{t^{n+1}+t^n}{2} - \frac{t^n + t^{n-1}}{2},$$

$$\Delta t^{n+\frac{1}{2}} = t^{n+1} - t^n.$$

Let us divide the Laplace coordinates into $r_j(j = 0, 1, \cdots, J)$ $r_J = r_{\text{side}}$. $\Delta r_{j-\frac{1}{2}} = r_j - r_{j-1}$

Let

$$-\frac{\partial u}{\partial t} = N \tag{2.1}$$

$$N = \frac{1}{\rho}\frac{\partial}{\partial R}\left(p + q + \frac{B^2}{8\pi}\right) + \frac{B^2}{4\pi\rho}, \tag{2.2}$$

Integrating Equation (2.1) with respect to t, we get

$$\int_{t^{n-\frac{1}{2}}}^{t^{n+\frac{1}{2}}} -\frac{\partial u}{\partial t}\,dt = -(u^{n+\frac{1}{2}} - u^{n-\frac{1}{2}}),$$

$$\int_{t^{n-\frac{1}{2}}}^{t^{n+\frac{1}{2}}} N\,dt \doteq N^n(t^{n+\frac{1}{2}} - t^{n-\frac{1}{2}}) = N^n\Delta t^n.$$

Multiplying Equation (2.2) by Rρ and integrating it with respect to R, we get

$$\text{left side} = \int_{R_{j-\frac{1}{2}}}^{R_{j+\frac{1}{2}}} N\rho R\,dR \doteq N_j \int_{R_{j-\frac{1}{2}}}^{R_{j+\frac{1}{2}}} R\rho\,dR$$

$$= N_j \frac{1}{4}\left(\rho_{j-\frac{1}{2}}(R_j^2 - R_{j-1}^2) + \rho_{j+\frac{1}{2}}(R_{j+1}^2 - R_j^2)\right)$$

$$= N_j \frac{1}{4}\left[\rho_{0j-\frac{1}{2}}(r_j^2 - r_{j-1}^2) + \rho_0(r_{j+1}^2 - r_j^2)\right]$$

$$= N_j \frac{1}{4}\left[m_{0j-\frac{1}{2}} + m_{0j+\frac{1}{2}}\right],$$

where $m_{0j+\frac{1}{2}} = \rho_{0j+\frac{1}{2}}(r_{j+1}^2 - r_j^2)$;

$$\text{right side} = \int_{R_{j-\frac{1}{2}}}^{R_{j+\frac{1}{2}}} \left(R\frac{\partial}{\partial R}\left(p + q + \frac{B^2}{8\pi}\right) + \frac{B^2}{4\pi}\right) dR$$

$$= R_j \int_{R_{j-\frac{1}{2}}}^{R_{j+\frac{1}{2}}} \frac{\partial}{\partial R}\left(p + q + \frac{B^2}{8\pi}\right) dR + \int_{R_{j-\frac{1}{2}}}^{R_{j+\frac{1}{2}}} \frac{B^2}{4\pi} dR$$

$$\doteq R_j(p_{j+\frac{1}{2}} + q_{i+\frac{1}{2}} - p_{i-\frac{1}{2}} - q_{i-\frac{1}{2}}) + R_j \frac{1}{8\pi}(B^2_{j+\frac{1}{2}} - B^2_{j-\frac{1}{2}})$$

$$+ \frac{B^2_{+\frac{1}{2}}}{8\pi}(R_{j+1} - R_j) + \frac{B^2_{j-\frac{1}{2}}}{8\pi}(R_j - R_{j-1}).$$

Therefore

$$N^n_j = \frac{4[R^n_j(p^n_{j+\frac{1}{2}} + q^{n-\frac{1}{2}}_{j+\frac{1}{2}} - p^n_{j-\frac{1}{2}} - q^{n-\frac{1}{2}}_{j-\frac{1}{2}}) + ((B^n_{j+\frac{1}{2}})^2 R^n_{j+1} - (B^n_{j-\frac{1}{2}})^2 R^n_{j-1})/8\pi]}{m_{0j-\frac{1}{2}} + m_{0j+\frac{1}{2}}}.$$

Finally

$$u^{n+\frac{1}{2}}_j = u^{n-\frac{1}{2}}_j$$

$$- \frac{4\Delta t^n[R^n_j(p^n_{j+\frac{1}{2}} + q^{n-\frac{1}{2}}_{j+\frac{1}{2}} - p^n_{j-\frac{1}{2}} - q^{n-\frac{1}{2}}_{j-\frac{1}{2}}) + ((B^n_{j+\frac{1}{2}})^2 R^n_{j+1} - (B^n_{j-\frac{1}{2}})^2 R^n_{j-1}/8\pi]}{m_{0j-\frac{1}{2}} + m_{0j+\frac{1}{2}}} \quad (2.3)$$

When $R_J = R_{J<}$ ($R_{J<}$ is the inner wall radius of the cavity), because pressure is 0 in vacuum

$$\text{left side} = \int_{R_{j<-\frac{1}{2}}}^{R_{j<}} N\rho R\,dR \doteq N_{j<} \int_{R_{j<-\frac{1}{2}}}^{R_{j<}} \rho R\,dR$$

$$= N_{j<} \frac{1}{4} \rho_{j<-\frac{1}{2}}(R^2_{j<} - R^2_{j<-1})$$

$$= N_{j<} \frac{1}{4} m_{0j<-\frac{1}{2}};$$

$$\text{right side} = \int_{R_{j<-\frac{1}{2}}}^{R_{j<}} \left(R \frac{\partial}{\partial R}\left(p + q + \frac{B^2}{8\pi}\right) + \frac{B^2}{4\pi}\right) dR$$

$$\doteq R_{j<}\left[\left(p + q + \frac{B^2}{8\pi}\right)\Big|_{R_{j<-\frac{1}{2}}}^{R_{j<}}\right] + \frac{B^2_{j<-\frac{1}{2}}}{8\pi}(R_{j<} - R_{j<-1})$$

$$\doteq -R_{j<}(p_{j<-\frac{1}{2}} + q_{j<-\frac{1}{2}}) + (R_{j<}B^2_{j<} - R_{j<-1}B^2_{j<-\frac{1}{2}})/8\pi$$

$$\doteq -R_{j<}(p_{j<-\frac{1}{2}} + q_{j<-\frac{1}{2}}) + \left(\frac{(((R_{j>} + R_{j<})/2)B_{j<+\frac{1}{2}})^2}{R_{j<}} - R_{j<-1}B^2_{j<-\frac{1}{2}}\right)/8\pi.$$

Hence

$$N^n_{j<} =$$

$$\frac{4(R^n_{j<}(-p^n_{j<-\frac{1}{2}} - q^{n-\frac{1}{2}}_{j<-\frac{1}{2}}) + ((B^n_{j<+\frac{1}{2}}(R^n_{j>} + R^n_{j<})/2)^2/R^n_{j<} - R^n_{j<-1}(B^n_{j<-\frac{1}{2}})^2)/8\pi)}{m_{0j<-\frac{1}{2}}}.$$

Finally

$$u^{n+\frac{1}{2}}_{j<} = u^{n-\frac{1}{2}}_{j<}$$

$$- \frac{4\Delta t^n[R^n_{j<}(-p^n_{j<-\frac{1}{2}} - q^{n-\frac{1}{2}}_{j<-\frac{1}{2}}) + ((B^n_{j<+\frac{1}{2}}(R^2_{j>} + R^2_{j<})/2)^2/R^n_{j<} - R^n_{j<-1}(B^n_{j<-\frac{1}{2}})^2)/8\pi]}{m_{0j<-\frac{1}{2}}}. \quad (2.4)$$

$$u_{j>}^{n+\frac{1}{2}} = u_{j>}^{n-\frac{1}{2}}$$

$$- \frac{4\Delta t^n [R_{j>}^n (p_{j>+\frac{1}{2}}^n + q_{j>+\frac{1}{2}}^{n-\frac{1}{2}}) + (R_{j>+1}^n (B_{j>+1}^n)^2 - (((R_{j>}^n + R_{j<}^n)/2) B_{j<+\frac{1}{2}}^n)^2 / R_{j>}^n)/8\pi]}{m_{0j>+\frac{1}{2}}}.$$

When $R = R_{JB}$ (which represents when $R \geqslant R_{JB}$, $B = 0$), we get

$$u_{JB}^{n+\frac{1}{2}} = u_{JB}^{n-\frac{1}{2}}$$

$$- \frac{4\Delta t^n [R_{JB}^n (p_{JB+\frac{1}{2}}^n + q_{JB+\frac{1}{2}}^{n-\frac{1}{2}} - p_{JB-\frac{1}{2}}^n - q_{JB-\frac{1}{2}}^{n-\frac{1}{2}}) - (B_{JB-\frac{1}{2}}^n)^2 R_{JB-1}^n / 8\pi]}{m_{0JB-\frac{1}{2}} + m_{0JB+\frac{1}{2}}}. \quad (2.5)$$

In the region $B = 0$, we have

$$u_j^{n+\frac{1}{2}} = u_j^{n-\frac{1}{2}} - \frac{4\Delta t^n [R_j^n (p_{j+\frac{1}{2}}^n + q_{j+\frac{1}{2}}^{n-\frac{1}{2}}) - p_{j-\frac{1}{2}}^n - q_{j-\frac{1}{2}}^{n-\frac{1}{2}})]}{m_{0j-\frac{1}{2}} + m_{0j+\frac{1}{2}}}. \quad (2.6)$$

When $i = J$, using $(p + q)|_{R_J} = 0$, we get

$$u_J^{n+\frac{1}{2}} = u_J^{n-\frac{1}{2}} + \frac{4\Delta t^n R_J^n (p_{J-\frac{1}{2}}^n + q_{J-\frac{1}{2}}^{n-\frac{1}{2}})}{m_{0J-\frac{1}{2}}}, \quad (2.7)$$

Obviously,

$$u_0^{n+\frac{1}{2}} = 0. \quad (2.8)$$

(2) The difference scheme for (1.B.2) is

$$\begin{cases} R_0^{n+1} = 0, \\ R_j^{n+1} = R_j^n + \Delta t^{n+\frac{1}{2}} u_j^{n+\frac{1}{2}}, \quad j = 1, 2, \cdots, J. \end{cases} \quad (2.9)$$

(3) The difference scheme for (1.B.3) is

$$\rho_{j+\frac{1}{2}}^n = \frac{m_{0j+\frac{1}{2}}}{(R_{j+1}^{n+1})^2 - (R_j^{n+1})^2}, \quad j = 0, 1, \cdots, J-1. \quad (2.10)$$

(4) The difference scheme for (1.B.4) is

$$q_{j+\frac{1}{2}}^{n+\frac{1}{2}} = \begin{cases} \frac{a^2}{2}(\rho_{j+\frac{1}{2}}^{n+1} + \rho_{j+\frac{1}{2}}^n)(u_{j+1}^{n+\frac{1}{2}} - u_j^{n+\frac{1}{2}})^2, & \text{when } u_{j+1}^{n+\frac{1}{2}} - u_j^{n+\frac{1}{2}} < 0, \\ 0, & \text{when } u_{j+1}^{n+\frac{1}{2}} - u_j^{n+\frac{1}{2}} \geqslant 0, \end{cases} \quad (2.11)$$

where α is a constant, which is selected according to the computation model.

(5) The difference equation for (1.B.5) is

$$\text{left side}=\frac{\varepsilon_{j+\frac{1}{2}}^{n+1}-\varepsilon_{j+\frac{1}{2}}^{n}}{\triangle t^{n+\frac{1}{2}}}+\left(\frac{p_{j+\frac{1}{2}}^{n+1}+p_{j+\frac{1}{2}}^{n}}{2}+q_{j+\frac{1}{2}}^{n+\frac{1}{2}}\right)\left(\frac{1}{\rho_{j+\frac{1}{2}}^{n+1}}-\frac{1}{\rho_{j+\frac{1}{2}}^{n}}\right)/\triangle t^{n+\frac{1}{2}},$$

$$\text{right side}=N=-\frac{\nu_m}{4\pi\rho}\left(\frac{1}{R}\frac{\partial(RB)}{\partial R}\right)^2=-\frac{1}{4\pi\rho\nu_m}\left(\frac{\nu_m}{R}\frac{\partial(RB)}{\partial R}\right)^2.$$

Let $M=-\frac{\nu_m}{R}\frac{\partial(RB)}{\partial R}$, then

$$N=\frac{1}{4\pi\rho\nu_m}M^2,$$

$$N_{j+\frac{1}{2}}^{n}=\frac{1}{2}\left(N_{j+\frac{1}{2}}^{n+1}+N_{j+\frac{1}{2}}^{n}\right)$$

$$-\frac{1}{2}\left[\frac{((M_{j+1}^{n+1}+M_j^{n+1})/2)^2}{4\pi\rho_{j+\frac{1}{2}}^{n+1}\nu_{mj+\frac{1}{2}}^{n+1}}+\frac{((M_{j+1}^{n}+M_j^{n})/2)^2}{4\pi\rho_{j+\frac{1}{2}}^{n+1}\nu_{mj+\frac{1}{2}}^{n}}\right].$$

Finally, we have

$$\varepsilon_{j+\frac{1}{2}}^{n+1}=\varepsilon_{j+\frac{1}{2}}^{n}-\left(\frac{p_{j+\frac{1}{2}}^{n+1}+p_{j+\frac{1}{2}}^{n}}{2}+q_{j+\frac{1}{2}}^{n+\frac{1}{2}}\right)\left(\frac{1}{\rho_{j+\frac{1}{2}}^{n+1}}-\frac{1}{\rho_{j+\frac{1}{2}}^{n}}\right)+Q_{j+\frac{1}{2}}^{n+\frac{1}{2}},\qquad(2.12)$$

Where

$$Q_{j+\frac{1}{2}}^{n+\frac{1}{2}}=\begin{cases}N_{j+\frac{1}{2}}^{n+\frac{1}{2}}\triangle t^{n+\frac{1}{2}}, & j=0,\cdots,JB-1,\\ 0, & j=JB,\cdots,J-1.\end{cases}$$

(6) The formula for (1.B.6) is

$$p_{j+\frac{1}{2}}^{n+1}=(\rho_{j+\frac{1}{2}}^{n+1},\ \varepsilon_{j+\frac{1}{2}}^{n+1}).\qquad(2.13)$$

(7) The difference equation of (1.B.7) is

$$\begin{cases}\dfrac{\partial}{\partial t}\left(B\dfrac{\partial R}{\partial r}\right)=N, & (2.14)\\ N=\dfrac{\partial}{\partial r}\left(\dfrac{\nu_m}{R}\dfrac{\partial(RB)}{\partial R}\right), & (2.15)\end{cases}$$

The following difference scheme is obtained using the above method:

$$N_{j+\frac{1}{2}}^{n+\frac{1}{2}}=\frac{1}{\triangle t^{n+\frac{1}{2}}}\left[B_{j+\frac{1}{2}}^{n+1}\left(\frac{\partial R}{\partial r}\right)\Big|_{j+\frac{1}{2}}^{n+1}-B_{j+\frac{1}{2}}^{n}\left(\frac{\partial R}{\partial r}\right)\Big|_{j+\frac{1}{2}}^{n}\right]$$

$$=\frac{1}{\triangle t^{n+\frac{1}{2}}}\left[B_{j+\frac{1}{2}}^{n+1}\frac{R_{j+1}^{n+1}-R_j^{n+1}}{r_{j+1}-r_j}-B_{j+\frac{1}{2}}^{n}\frac{R_{j+1}^{n}-R_j^{n}}{r_{j+1}-r_j}\right]$$

$$=\frac{1}{\triangle t^{n+\frac{1}{2}}(r_{j+1}-r_j)}\left[B_{j+\frac{1}{2}}^{n+1}(R_{j+1}^{n+1}-R_j^{n+1})-B_{j+\frac{1}{2}}^{n}(R_{j+1}^{n}-R_j^{n})\right].$$

The difference scheme for equation (2.15) is

$$N_{j+\frac{1}{2}}^{n+\frac{1}{2}} = \frac{1}{2}\left(N_{j+\frac{1}{2}}^{n+1} + N_{j+\frac{1}{2}}^{n}\right)$$
$$- \frac{1}{2}\left(\frac{M_{j+1}^{n+1} - M_j^{n+1}}{r_{j+1} - r_j} + \frac{M_{j+1}^{n} - M_j^{n}}{r_{j+1} - r_j}\right)$$
$$- \frac{1}{r_{j+1} - r_j}\left(\frac{M_{j+1}^{n+1} - M_j^{n+1}}{2} + \frac{M_{j+1}^{n} - M_j^{n}}{2}\right).$$

M_J is determined as the following:

$$M = \frac{v_m}{R}\frac{\partial(RB)}{\partial R},$$

Multiplying both sides by R/v_m and integrating with respect to R, we get

$$\text{left side} = \int_{R_{j-\frac{1}{2}}}^{R_{j+\frac{1}{2}}} \frac{R}{v_m} M\,dR = M_j R_j \int_{R_{j-\frac{1}{2}}}^{R_{j+\frac{1}{2}}} \frac{dR}{v_m}$$

$$= M_j R_j \left(\frac{R_j - R_{j-1}}{v_{mj-\frac{1}{2}}} + \frac{R_{j+1} - R_j}{v_{mj+\frac{1}{2}}}\right)/2,$$

$$\text{right side} = (RB)\Big|_{R_{j-\frac{1}{2}}}^{R_{j+\frac{1}{2}}} = \frac{R_{j+1} + R_j}{2} B_{j+\frac{1}{2}} - \frac{R_j + R_{j-1}}{2} B_{j-\frac{1}{2}},$$

Hence,

$$M_j = \frac{(R_{j+1} + R_j)B_{j+\frac{1}{2}} - (R_j + R_{j-1})B_{j-\frac{1}{2}}}{R_j\left((R_{j+1} - R_j)/v_{mj+\frac{1}{2}} + (R_j - R_{j-1})/v_{mj-\frac{1}{2}}\right)}$$
$$= 2K_j^+ B_{j+\frac{1}{2}} - 2K_j^- B_{j-\frac{1}{2}},$$

where

$$K_j^+ = (R_{j+1} + R_j)/K_j,$$
$$K_j^- = (R_j + R_{j-1})/K_j,$$
$$K_j = 2R_j\left((R_{j+1} - R_j)/v_{mj+\frac{1}{2}} + (R_j - R_{j-1})/v_{mj-\frac{1}{2}}\right).$$

When $R = R_{J<}$,

$$\text{left side} = \int_{R_{j<-\frac{1}{2}}}^{R_{j<}} \frac{R}{v_m} M\,dR = R_{j<} M_{j<} \frac{(R_{j<} - R_{j<-1})}{2v_{mj<-\frac{1}{2}}},$$

$$\text{right side} = (RB)\Big|_{R_{j<-\frac{1}{2}}}^{R_{j<}}$$
$$= \frac{R_{j>} + R_{j<}}{2} B_{j<+\frac{1}{2}} - \frac{R_{j<} + R_{j<-1}}{2} B_{j<-\frac{1}{2}},$$

Therefore

$$M_{j<} = \frac{(R_{j>} + R_{j<})B_{j<+\frac{1}{2}} - (R_{j<} + R_{j<-1})B_{j<-\frac{1}{2}}}{R_{j<}(R_{j<} - R_{j<-1})/v_{mj<-\frac{1}{2}}}.$$

Because $\sigma_{i<+\frac{1}{2}} = 0$, therefore $1/\nu_{mj<+\frac{1}{2}} = 0$. Thus, $M_{J<}$ can be written as

$$M_{i<} = \frac{(R_{i>} + R_{i<})B_{i<+\frac{1}{2}} - (R_{i<} + R_{i<-1})B_{i<-\frac{1}{2}}}{R_{i<}((R_{i<} - R_{i<-1})/\nu_{mi<-\frac{1}{2}} + (R_{i>} - R_{i<})/\nu_{mi<+\frac{1}{2}})}$$
$$= 2K_i^+ B_{i<+\frac{1}{2}} - 2K_i^- B_{i<-\frac{1}{2}}.$$

When $R = R_{J>}$

$$\text{left side} = \int_{R_{i<}}^{R_{i<+\frac{1}{2}}} \frac{R}{\nu_m} M dR = M_{i>}R_{i<}\frac{R_{i>+1} - R_{i>}}{2\nu_{mi>+\frac{1}{2}}}$$
$$= M_{i>}R_{i>}\left[\frac{R_{i>+1} - R_{i>}}{\nu_{mi>+\frac{1}{2}}} + \frac{R_{i>} - R_{i\leq}}{\nu_{mi<+\frac{1}{2}}}\right]/2,$$

$$\text{right side} = (RB)\Big|_{R_{i>}}^{R_{i>+\frac{1}{2}}}$$
$$= \frac{R_{i>+1} + R_{i>}}{2} B_{i>+\frac{1}{2}} - \frac{R_{i<} + R_{i<+1}}{2} B_{i<+\frac{1}{2}},$$

Hence

$$M_{i>} = 2K_{i>}^+ B_{i>+\frac{1}{2}} - 2K_{i>}^- B_{i>-\frac{1}{2}}.$$

When $R = R_{JB}$, similar to $M_{j<}$, we have

$$M_{JB} = 2K_{JB}^+ B_{JB+\frac{1}{2}} - 2K_{JB}^- B_{JB-\frac{1}{2}}.$$

Based on the computation model, we choose

$$1/\nu_{mJB+\frac{1}{2}} = 0, \quad B_{JB+\frac{1}{2}} = 0.$$

When $R = 0$, in analogy to the above derivation, we have

$$M_0 = 2/(R_1/\nu_{m\frac{1}{2}})B_{\frac{1}{2}}.$$

(8) Solving the Difference Equation

Equation (1.B.7) can be rearranged and written as follows:

$$-(K_i^-)^{n+1} B_{i-\frac{1}{2}}^{n+1} + D_{i+\frac{1}{2}}^{n+1} B_{i+\frac{1}{2}}^{n+1} - (K_i^+)^{n+1} B_{i+\frac{1}{2}}^{n+1} = G_{i+\frac{1}{2}}^n \quad i = 0, \cdots, JB - 1, \tag{2.16}$$

where

$$G_{i+\frac{1}{2}}^n = \frac{1}{2}(M_{i+1}^n - M_i^n) + \frac{1}{\Delta t^{n+\frac{1}{2}}}$$
$$\times \begin{cases} (R_{i+1}^n - R_i^n)B_{i+\frac{1}{2}}^n, & i = 0, \cdots, JB - 1, \ i \neq i< \\ \left[\dfrac{(R_{i>}^n + R_{i<}^n)}{2}\ln\left(\dfrac{R_{i>}^n}{R_{i<}^n}\right)\right] B_{i<+\frac{1}{2}}^n, & i = i<, \end{cases} \tag{2.17}$$

$$D_{i+\frac{1}{2}}^{n+1} = (K_{i+1}^-)^{n+1} + (K_i^+)^{n+1} + \frac{1}{\Delta t^{n+\frac{1}{2}}}$$
$$\times \begin{cases} (R_{i+1}^{n+1} - R_i^{n+1}), & i = 0, \cdots, JB - 1, \ i \neq i< \\ \dfrac{(R_{i<+1}^{n+1} + R_{i<}^{n+1})}{2}\ln\left(\dfrac{R_{i<+1}^{n+1}}{R_{i<}^{n+1}}\right), & i = i<. \end{cases} \tag{2.18}$$

Both Equations (2.12) and (2.16) are nonlinear. Equation (2.12) is solved by a simple iteration method. The iteration formula is as follows:

$$\begin{cases} p_{j+\frac{1}{2}}^{n+1(s)} = p(\varepsilon_{j+\frac{1}{2}}^{n+1(s)}, \rho_{j+\frac{1}{2}}^{n+1}), \\ \varepsilon_{j+\frac{1}{2}}^{n+1(s+1)} = \left[\left(\frac{1}{\rho_{j+\frac{1}{2}}^{n}} - \frac{1}{\rho_{j+\frac{1}{2}}^{n+1}}\right)/2\right] p_{j+\frac{1}{2}}^{n+1(s)} \\ \quad + \varepsilon_{j+1}^{n} - \left(\frac{p_{j+\frac{1}{2}}^{n}}{2} + q_{j+\frac{1}{2}}^{n+\frac{1}{2}}\right)\left(\frac{1}{\rho_{j+\frac{1}{2}}^{n+1}} - \frac{1}{\rho_{j+\frac{1}{2}}^{n}}\right) + Q_{j+\frac{1}{2}}^{n+\frac{1}{2}} \end{cases} \tag{2.19}$$

Here, s represents the number of iterations. $p_{j+1}^{n+1(0)}$ is chosen to be $p_{j+\frac{1}{2}}^{n}$, and $\varepsilon_{j+\frac{1}{2}}^{n+1(0)}$ is $\varepsilon_{j+\frac{1}{2}}^{n}$.

Equation (2.16) must be solved by successive convergent iteration. Its formula is

$$\begin{cases} W_{j+\frac{1}{2}} = (K_{j+1}^{+})^{n+1(s)} / (D_{j+\frac{1}{2}}^{n+1(s)} - (K_j^{-})^{n+1(s)} W_{j-\frac{1}{2}}), \\ V_{j+\frac{1}{2}} = (G_{j+\frac{1}{2}}^{n} + (K_j^{-})^{n+1(s)} V_{j-\frac{1}{2}}) / (D_{j+\frac{1}{2}}^{n+1(s)} - (K_j^{-})^{n+1(s)} W_{j-\frac{1}{2}}), \\ \qquad j = 0, \cdots, JB-1, \\ \qquad V_{-\frac{1}{2}} = W_{-\frac{1}{2}} = 0, \\ B_{j+\frac{1}{2}}^{n+1(s+1)} = W_{j+\frac{1}{2}} B_{j+\frac{1}{2}}^{n+1(s+1)} + V_{j+\frac{1}{2}}, \; j = JB-1, \cdots, 0, \end{cases} \tag{2.20}$$

where s is the number of iterations. When s = 0, the value at a prior moment is used as the initial value in iteration.

When the inner and outer wall are in contact, the empty cavity is removed.

2. Difference Equation for B = (U,U,B(r,t))

Because the structure of the scheme and the method are totally similar to the case of B = (0,B(r,t),0), therefore, it will not be described in detail. The final results are summarized as follows:

$$\begin{cases} m_{0j+\frac{1}{2}} = \rho_{0j+\frac{1}{2}}(r_{j+1}^2 - r_j^2), \ j = 0, \cdots, J-1, \\ m_{0J+\frac{1}{2}} = p_{J+\frac{1}{2}}^{n} = q_{J+\frac{1}{2}}^{n-\frac{1}{2}} = B_{JB+\frac{1}{2}}^{n} = B_{JB+\frac{1}{2}}^{n+1} = 0, \end{cases} \tag{2.21}$$

$$\begin{cases} u_0^{n+\frac{1}{2}} = 0, \\ u_j^{n+\frac{1}{2}} = u_j^{n-\frac{1}{2}} - 4\Delta t^n R_j^n \left\{ p^n{}_{j+\frac{1}{2}} + q_{i+\frac{1}{2}}^{n-\frac{1}{2}} - p_{i-\frac{1}{2}}^{n} - q_{i-\frac{1}{2}}^{n-\frac{1}{2}} \right. \\ \qquad \left. + \frac{1}{8\pi}\left((B_{i+\frac{1}{2}}^{n})^2 - (B_{i-\frac{1}{2}}^{n})^2\right)\right\} / (m_{0i-\frac{1}{2}} + m_{0i+\frac{1}{2}}), \\ \qquad j = 1, \cdots, J. \end{cases} \tag{2.22}$$

$$\begin{cases} R_0^{n+1} = 0, \\ R_j^{n+1} = R_j^n + \Delta t^{n+\frac{1}{2}} u_j^{n+\frac{1}{2}}, \ j = 1, 2, \cdots, J. \end{cases} \tag{2.23}$$

When $R_{j>}^{n+1} \leqslant R_{j<}^{n+1}$, the following treatment is performed:

$$(R_{j>}^{n+1} + R_{j<}^{n+1})/2 \Rightarrow R_{j<}^{n+1}, \ R_{j>}^{n+1},$$

$$u_{j>}^{n+1} \Rightarrow u_{j>}^{n+\frac{1}{2}}, \ u_{j<}^{n+\frac{1}{2}},$$

$$\rho_{j+\frac{1}{2}}^{n+1} = m_{0j+\frac{1}{2}}/((R_{j+1}^{n+1})^2 - (R_j^{n+1})^2), \ j = 0, \cdots, J-1,$$

$$q_{j+\frac{1}{2}}^{n+\frac{1}{2}} = \begin{cases} \frac{a^2}{2}(\rho_{j+\frac{1}{2}}^{n+1} + \rho_{j+\frac{1}{2}}^{n})(u_{j+1}^{n+\frac{1}{2}} - u_j^{n+\frac{1}{2}})^2, & \text{when } u_{j+1}^{n+\frac{1}{2}} - u_j^{n+\frac{1}{2}} < 0, \\ 0, & \text{when } u_{j+1}^{n+\frac{1}{2}} - u_j^{n+\frac{1}{2}} \geqslant 0, \\ & j = 0, \cdots, J-1, \end{cases} \tag{2.24}$$

$$\begin{cases} K_j = 2R_j/((R_j - R_{j-1})/v_{mj-\frac{1}{2}} + (R_{j+1} - R_j)/v_{mj+\frac{1}{2}}), \\ M_j = K_j(B_{j+\frac{1}{2}} - B_{j-\frac{1}{2}}), \quad j = 1, \cdots, JB \\ M_0 = 0, \end{cases} \tag{2.25}$$

$$Q_{j+\frac{1}{2}}^{n+\frac{1}{2}} = \begin{cases} \frac{\Delta t^{n+\frac{1}{2}}}{8\pi}\left\{ \frac{(M_{j+1}^{n+1} + M_j^{n+1})^2}{(R_{j+1}^{n+1} + R_j^{n+1})\rho_{j+\frac{1}{2}}^{n+1} v_{mj+\frac{1}{2}}^{n+1}} + \frac{(M_{j+1}^{n} + M_j^{n})^2}{(R^n{}_{j+1} + R_j^n)\rho_{j+\frac{1}{2}}^{n} v_{mj+\frac{1}{2}}^{n}} \right\}, \\ \qquad j = 0, \cdots, JB-1 \ j \neq j_<, \\ 0, \quad j = JB, \cdots, J-1, \ j_<, \end{cases}$$

$$\begin{cases} p_{j+\frac{1}{2}}^{n+1(s)} = p(\varepsilon_{j+\frac{1}{2}}^{n+1(s)}, \ \rho_{j+\frac{1}{2}}^{n+1}), \\ \varepsilon_{j+\frac{1}{2}}^{n+1(s+1)} = \left[\left(\frac{1}{\rho_{j+\frac{1}{2}}^{n}} - \frac{1}{\rho_{j+\frac{1}{2}}^{n+1}}\right)\Big/2\right] p_{j+\frac{1}{2}}^{n+1(s)} \\ \quad + \varepsilon_{j+\frac{1}{2}}^{n} - \left(\frac{p_{j+\frac{1}{2}}^{n}}{2} + q_{j+\frac{1}{2}}^{n+\frac{1}{2}}\right)\left(\frac{1}{\rho_{j+\frac{1}{2}}^{n+1}} - \frac{1}{\rho_{j+\frac{1}{2}}^{n}}\right) + Q_{j+\frac{1}{2}}^{n+\frac{1}{2}}, \\ \qquad j = 0, \cdots, J-1, \ j \neq j_< \end{cases} \tag{2.26}$$

$$\begin{cases} D^{n+1}_{j+\frac{1}{2}} = K^{n+1}_{j+1} + K^{n+1}_{j} + [(R^{n+1}_{j+1})^2 - (R^{n+1}_{j})^2]/\Delta t^{n+\frac{1}{2}}, \\ G^{n}_{j+\frac{1}{2}} = M^{n}_{j+1} - M^{n}_{j} + B^{n}_{j+\frac{1}{2}}[(R^{n}_{j+1})^2 - (R^{n}_{j})^2]/\Delta t^{n+\frac{1}{2}}, \\ \qquad j = 1, \cdots, JB-1, \end{cases} \tag{2.27}$$

$$-K^{n+1(G)}_{j} B^{n+1(G+1)}_{j-\frac{1}{2}} + D^{n+1(G)}_{j+\frac{1}{2}} B^{n+1(G+1)}_{j+\frac{1}{2}} - K^{n+1(G)}_{j+1} B^{n+1(G+1)}_{j+\frac{1}{2}} = G^{n}_{j+\frac{1}{2}}. \tag{2.28}$$

The successive convergent iteration formula is:

$$\begin{cases} W_{j+\frac{1}{2}} = K^{n+1(G)}_{j+1} / (D^{n+1(G)}_{j+\frac{1}{2}} - K^{n+1(G)}_{j} W_{j-\frac{1}{2}}) \\ V_{j+\frac{1}{2}} = (G^{n}_{j+\frac{1}{2}} + K^{n+1(G)}_{j} V_{j-\frac{1}{2}})/(D^{n+1(G)}_{j+\frac{1}{2}} - K^{n+1(G)}_{j} W_{j-\frac{1}{2}}) \\ \qquad j = 0, \cdots, JB-1 \end{cases} \tag{2.29}$$

$$W_{-\frac{1}{2}} = V_{-\frac{1}{2}} = 0$$

$$B^{n+1(G+1)}_{j+\frac{1}{2}} = W_{j+\frac{1}{2}} B^{n+1(G+1)}_{j+\frac{1}{2}} + V_{j+\frac{1}{2}}, \; j = JB-1, \cdots, 0.$$

§3. Treatment of a Problem and Its Stability Analysis

In the computation we found that the magnetic diffusion equation could not be accurately calculated in some media. The reason is that in the given pulse magnetic field the smoothing time τ_d for some media is $\tau_d \sim 10^{-16}$, which requires that the computation step $\Delta t < 10^{-16}$ to be able to give accurate results. This is obviously impossible to do. Because joule heating in these regions can be neglected, it is considered that magnetic diffusion does not require any time in these regions, i.e., the distribution of B is stable in these regions and there is no electrical conduction current, just as an empty cavity.

With regard to the selection of the time step it is as follows. The size of the time step is determined by the stability requirement of the difference scheme. There are two physical processes in our problem; (i) the mechanical motion caused by the initial intense shockwave in the outer layer and (ii) the diffusion process of the super magnetic field. They correspond to nonlinear hyperbolic systems and parabolic type equations in mathematics. In addition, the magnetic field generates another intense shockwave which is located in the middle of the system. It moves with time. Because there are different media, the system is made very complex due to the interaction of the empty cavity and the two shockwaves. It is more convenient to use Von Newmann's viscosity treatment. As for the stability condition of the motion, based on the results of reference [3], under cylindrical symmetry we have

$$\frac{c\Delta t}{\rho_0 V \Delta r}\left(\frac{R}{r}\right) \leqslant \frac{\sqrt{r}}{2a}.$$

Actual calculated results indicate that the above condition is essentially met. In the initial stage of the calculation, the shockwave is relatively strong and Δt is very small. With increasing time, the shockwave is weakened and Δt can be increased gradually. When the inner and outer wall of the cavity come into contact, Δt must again be very small. When the shockwave created by the magnetic field collides with the shockwave in the external region, the shockwave is strengthened again. Correspondingly, Δt has to be decreased. In conclusion, the size of Δt is basically determined by the magnitude of the artificial viscosity q. Generally, Δt is very small initially. It gradually increases and the difference may be several orders of magnitude.

On the other hand, the magnetic diffusion equation is a nonlinear parabolic type equation. With linear constant coefficients, a six-point symmetry scheme is definitely stable. It is also stable for certain nonlinear equations (see reference [3]). For our problem, the actual calculation shows that it is conditionally stable. The unstable effect is due to oscillation of the magnetic field, especially for a strong pulsed magnetic field. At the beginning of the calculation, the requirement on Δt is very strict. Mathematically, stability is determined by the "degree" of nonlinearity of the equation. The larger the diffusion coefficient and the more violent the change is, the smaller Δt must be.

A difference scheme may be established by taking heat conduction into consideration, in analogy to the case of magnetic diffusion equation (see reference [6]). We have also done a great deal of similar computation and the results show the scheme is effective. Appropriate patterns were obtained.

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APPLIED SCIENCES

OPINIONS ON NUCLEAR WASTE MANAGEMENT EXPRESSED

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[Text]

Abstract: In order to manage well radwastes from nuclear power plants the following four basic principles should be followed: 1) to strive to decrease the radwastes; 2) to strive to develop the volume reduction technology; 3) to develop a proper solidification technology; and 4) to realize final disposal which guarantees safety. These points are discussed in this paper.

Nuclear power plants release a great amount of waste gas, liquid, and solid in their operation process. Gaseous and liquid wastes may be released to the environment or recycled after they are purified to the acceptable standard. The amount of radioactive wastes depends on the type of the reactor, the power rating, design, operation, management, and maintenance of the power station, the nature of the incidence, and the waste processing technique. Different power plants produce widely different amounts of wastes, a 1000 MWe pressurized-water reactor [PWR] power plant generates 300-1000 m^3/yr of wastes. Assuming a power plant has 40 years of operating life and taking into account the wastes generated after its retirement, a 1000 MWe PWR power plant produces a total of 20,000-50,000 low and intermediate level radioactive solid wastes, a substantial amount indeed.

Nuclear power is one of China's high-priority energy sources for development. By the end of this century China is expected to have 10,000 MWe of nuclear power plants in operation. Assuming 2000 MWe of power plants are built in 1990 and 2000 MWe are built every 2 years therafter, then China can expect an accumulation of 36,000 m^3 of low and intermediate level radioactive solid wastes by the year 2000. If 1 m^3 of solidified waste fills one barrel, there would be 36,000 barrels (200 liters per barrel) requiring 72 storage chambers, each holding 5000 barrels and measuring 64x12x8m. If these wastes are buried in shallow strata with a stacking height of 4m, it would require 0.9 hectares of land. Most of China's nuclear power plants will be built in eastern,

central south, and northeastern China where electric power is in short supply. Since these are areas with well-developed industrial and agricultural production and have a high population density and land economic value, it is of utmost importance that radioactive wastes be handled safely and economically so that nuclear power may be further developed and the public health and the environment may be protected. To manage the radwastes from nuclear power plants, four basic principles must be followed:

1. Decrease the Generation of Low and Intermediate Level Radioactive Wastes

The low and intermediate level radioactive wastes are the pollution sources of the nuclear power industry. The strategy for handling such wastes should be a combination of prevention and treatment. Today, both the countries with developed nuclear power and the countries with developing nuclear power industry are paying great attention to the reduction of radwastes, taking it to be a high priority task in the management of waste gas, waste liquid and solid waste. Actions are taken in the design, construction and operation of the nuclear power plants and in the handling of the wastes.

In the selection of an engineering process, a process that produces less waste and favors waste handling is considered an advanced, rational, and economic process. The reactor structure and equipment should be made of high-quality, corosion-resistent materials that are easy to clean in order to improve the service life and reliability of the equipment and reduce the amount of maintenance and replacement necessary. The water quality of the coolant and the purity of the additives should be controlled and the generation of activated products should be kept to a minimum. The quality of irradiated components must be assured because component damage is a main source for radioactive fission products. Foreign power plants pay great attention to component quality and the actual damage ratio is only 0.01-0.02 percent.

Practical experiences have shown that the amount of wastes generated depends on the level of management. We need to strengthen the management, formulate sound and practical regulations, train and evaluate the operators, and educate all the workers so that they understand the importance of reducing radioactive wastes. Ideally a special task group should be formed to periodically examine the problems existing in waste management.

The waste gas from a nuclear power plant is usually catalytically hydrogenated, dried, compressed, and stored for about 60 days and then filtered by a high efficiency filter before being released into the atmosphere. The plant atmosphere may be released after going through activated charcoal and high efficiency filters. The waste water from a nuclear power plant, depending on the salt content, is treated with ion exchange, evaporation, and filtering. We should strive to improve the purification efficiency of waste gas and waste water treatment and recycle in order to reduce secondary wastes. Wastes should be collected and stored according to category to avoid cross-contamination. Ordinary refuse should be handled as such and we should never treat all the wastes from a nuclear power plant as radioactive wastes.

Contaminated equipment or components may be cleaned and reused, or treated as nonradioactive waste to reduce the volume of wastes. Common cleaning methods include chemical, ultrasonic, high-pressure water or steam jet, and electrolytic cleaning.[1] Improper use of detergents often produces many secondary wastes which are difficult to handle because of their strong corrosive nature. China has studied cleaning methods for a long time and has accumulated considerable experience, but there still remain a number of problems. To meet the needs of the nuclear power plants, we need to develop efficient detergent and cleaning methods in order to conduct decontamination without shutting down the reactor and to clean the evaporators, pumps and valves. Decontamination standards and codes are essential.

In addition, efforts should be spent to develop or import and apply general-purpose, sensitive, fast, and convenient monitors, especially the continuous monitors and controls for waste gas and liquid.

2. Develop Volume Reduction Technology

The volume of radioactive wastes already generated should be reduced as much as possible. Various volume reduction techniques should be developed in a major effort. Since 40-60 percent of the solid wastes produced by a nuclear power plant are combustible, burning can reduce the volume by 20-60 times. After burning, more than 70 percent of the radioactive elements are in the ash, which can then be compacted for final disposal. The radioactive waste incinerator should have safe and reliable waste loading and ash unloading systems and a high efficiency tail gas purification system. The design standards are stringent and the construction and operating costs are high. Generally speaking, it is not economical to install an incinerator for a single nuclear reactor; however, a common incinerator for a multireactor nuclear power plant or concentrated regional nuclear facilities is also effective and economical. Foreign nuclear power plants are currently developing incineration facilities. China has taken some preliminary steps in the design, construction, and operation of radwaste incinerators and efforts should be organized on this basis to design and build such facilities.

Although the volume reduction achieved by compaction (2-8 times) is not as large as that by incineration, the compaction apparatus is easier to operate and costs less to build and operate. An incinerator costs several million to 10 million yuan whereas a compaction facility costs only several tens or hundreds of thousand yuan. Compaction is therefore a low-cost alternative for volume reduction and is used widely in foreign power plants. Usually, 20-30-ton presses are used to compact the waste directly into the storage barrel or into blocks before loading into the barrel. Mobile compaction devices transported by truck have been built in West Germany to compress wastes into 15-30 cm thick disks for loading into 200-liter storage barrels.[2] Large-scale presses have also been used to compact the waste along with the barrel. The 400-ton press in Manche, France, compacts the storage barrel to reduce the volume even further. Ordinary presses may be easily converted to handle radwastes by installing suitable safety features.

The scrapped contaminated equipment or parts often have a large volume and may be compressed, crushed, or cut into small pieces to reduce their volume. The cutting and dismemberment technology is particularly important for the handling of large quantities of retired nuclear facilities and wastes. Parts taken from the nuclear reactor such as pipes and control rods are often highly radioactive and techniques for underwater demolition and cutting, plasma arc cutting, laser cutting, and electric arc sawing are therefore quite important. The research and development of such technology is still very weak in China.

3. Develop Solidification Technology

Most of the radioactive elements in radwastes would have decayed to a harmless level after a short period of storage, the remaining species -- Cs^{137}, Cs^{134}, Co^{60} and Sr^{90} -- would still have a radioactive level 10^3-10^6 times higher than the acceptable release level. The radwastes from a nuclear power plant should therefore be stored for 300-600 years. People have designed a multitude of shields to separate such radwastes from the human living environment. The first shield of protection is to solidify the radioactive wastes in a stable solid. The evaporation residue, waste resin, filter slush and incinerator ash are either high in moisture content or loose in form and tend to pollute the environment. They are also hard to transport, store, or handle and must be first solidified. The ideal solidification method should be safe and economical. The process itself should be safe and the solidified product should be safe to store. The release rate of radioactive elements should be low, the mechanical strength should be high and the thermal stability and radiation stability should be good. To be economical the waste content should be high and the equipment investment and operating costs should be low. The combined cost for solidification, transport, storage, and handling should be kept low to minimize capital outlay. Solification techniques already developed for low and intermediate radiation level wastes include cement solidification, bitumen solidification, and plastic solidification. Each has its own merits and shortcomings and each applies to certain types of wastes.[3]

The oldest and most commonly used method is cement solidification because its operation is simple and safe. However, it has two major drawbacks: 1) the waste content is low and hence the volume is large; and 2) the seepage rate of radioactive elements (such as Cs^{137}) is high. A number of methods have been developed to reduce the seepage rate, among them: 1) pretreat the waste liquid and precipitate out cesium with potassium ferrocyanide and remove cobalt with activated carbon; 2) mix in additives such as zeolite, rock, or bentonite; 3) cost the solidified cement with bitumen, polystyrene, or silicon tetrafluoride; and 4) use hot or cold solidification to increase the density. These methods may reduce the seepage rate considerably but also increase the volume and complicate the operation. Waste liquids may be turned into a dry power by evaporation before solidification to reduce the volume. In the hydraulic fissure method, the radioactive waste liquid, concrete grout and additive are injected into waterproof shale rock. This method places the waste directly into its storage location and is a viable method when the appropriate shale strata are available.

The waste content in bitumen solidification is 2-3 times higher than the cement solidification and the seepage rate is 1-2 orders of magnitude lower. The bitumen solidification method was used in the early 1960's in some European countries (Belgium, France, and West Germany). In mid-1970's there was some heated controversy over the safety of bitumen solidification. China also studied the safety of bitumen solidification and found that temperature control is crucial[4] and the temperature should be kept below 200°C. The sodium nitrate content of nuclear power plant wastes is low and experience shows that bitumen solidification can be safe as long as precautions and proper operating procedures are observed.

Plastic solidification is a relatively new technique. The first plastic solidification method uses urea-formaldehyde but the technique has been gradually phased out[5] because it produces acidic corrosive water in the solidification process. A number of new plastics are being developed including polystyrene, polyethylene, polyvinyl chloride, polyester, and epoxy. The advantages of plastic solidification are the high content of waste and the low seepage rate. For example, 100 m^3 of sodium sulfate waste liquid (10 g/l) produces 4 m^3 of residual liquid (250 g/l) after evaporation process. Using the cement solidification method, 40 barrels (200 l/barrel) of solidified waste weighing 22 tons will be produced. Using plastic solidification, only 7 barrels of solidified waste with a total weight of 2 tons will be produced[6], greatly reducing the need for transportation, storage, and burial space. Furthermore, wastes not suitable for cement solidification such as waste resin and TBP solvent may be satisfactorily solidified in plastic.[7] Because of this, plastic solidification has been developed fairly quickly in recent years.

Some countries today have switched to solidification methods with a high volume reduction ratio[8] because of shortage in storage site (like Japan) or increases in the cost of waste processing (like the U.S.). China has not fully developed its solidification technology, cement solidification of concentrated wastes and filter grout and polyethylene solidification of waste resin are viable approaches. We should conduct engineering tests of cement solidification of borate wastes and improve the solidification method, and we should also develop high content salt powder solidification and granular solidification.

Solidification apparatus transportable on trucks[9] have been developed in foreign countries in recent years. Since such equipment may be transported to the location of waste processing, the utilization is high and the economic benefits are great. It is an economical, rational and effective methods in regions where nuclear power stations and nuclear facilities are scattered.

4. Achieve Safe Final Disposal

Generally nuclear power stations are not equipped to handle the final disposal of radioactive solid wastes. Such solid wastes are usually stored in the temporary storage of the power plant for 5-10 years and then delivered to the final disposal site. Today nuclear power plants in other countries use three disposal methods: burial in shallow strata, storage in mines or rock caves, and disposal in the ocean.

Ocean disposal requires the most elaborate packaging and has the highest cost, and it has also met increasingly strong objections. A decision was made in the London meeting in February 1983 to temporarily halt disposal of radioactive wastes in the ocean.

Storage in abandoned mineshafts and in rock caves is safe but cost more than burial in shallow strata. A typical example of storage in an abandoned mineshaft is the salt mine at Asse in West Germany, where 140,000 barrels of low-grade radioactive waste and 1,3000 barrels of intermediate grade waste were stored. In addition to salt mines, there are also plans to store nuclear waste in iron mines, uranium mines, gypsum mines, and limestone mines. Sweden and Switzerland are also studying the installation of nuclear waste storage facilities in rock caves.[10,11]

Burial in shallow strata is easy to implement at low cost and is most often used. The types of structures used include ditches, wells, underground cellars, and surface mounds. Ditches of various sizes are used most often, the typical dimensions are 30-240 m long, 10-15 m wide and 6-10 m deep, and they are constructed of concrete. Waste with a high level of radioactivity such as waste resin and used filter elements is best stored in wells. There are different types of wastes of different radioactive levels. Water is the most likely medium to transport the radioactive elements and the control of ground water and surface water is therefore very important. The surrounding soil should be able to adsorb, exchange, and retain the radioactive material and prevent it from migrating. The site selection requires detailed geological and hydrological survey and environmental impact and safety factors are considered. Measures must be taken in the construction of such storage facilities to prevent ground water and surface from entering the storage zone. After the disposal site is closed, it should be monitored and maintained for a long period of time to prevent the exposure of the radioactive material caused by soil and water loss and weathering erosion. The long experience of shallow strata burial gained by the United States, France, the United Kingdom, Canada, and the Soviet Union has shown that, as long as the burial sites are properly chosen and carefully managed, the radioactive waste can be separated from the living environment of human beings for 500-600 years.

At the present time China is considering building nuclear power plants in the eastern coastal area. This is a humid and rainy area and metallic storage barrels may corode if they are left in temporary storage sites for a long time. We should begin coordinating and planning the storage and disposal tasks and build the necessary structures at an early date to avoid future problems.

Based on the experience accumulated by foreign countries and the actual situation in China, we should employ the shallow burial method and storage in abandoned mines and rock caves as local circumstances permit. Because of the large size of China, a centralized disposal scheme would require long-distance transportation of the nuclear waste and would lead to additional costs and safety concerns. We should therefore construct local disposal sites and do so based on a rational scheme. We suggest that hydrological and geological surveys be conducted first in eastern China and in the central south region

and next in the northeast or Nei Monggol and a number of candidate sites be chosen for environmental impact studies. The selection of the disposal sites should be finalized after sufficient comparison and investigation. Three disposal sites of the size of the Manche disposal site in France should be built in the above three regions. (The Manche disposal field has a volume of 400,000 m^3, occupies 12 hectares of land and cost 150 million Francs, equivalent to 30 million yuan). These three disposal sites are expected to satisfy the nuclear waste disposal needs for nuclear power plants and radioactive wastes generated by isotopes and nuclear technology applications to the year 2020.

In order to base our site selection, design, construction and operation of nuclear disposal facilities on scientific, rational, and safe and reliable grounds, we should organize an effort to formulate standards, codes, and regulations and at the same time develop the necessary scientific research.

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APPLIED SCIENCES

CHINA DEVELOPS 6J KrF LASER

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5, No 1, Mar 85 pp 1-5

[Article by Wang Ganchang [3769 3227 2490], Zhu Xuhui [6175 2485 6540], Wang Naiyan [3769 0035 1750], Xie Jinggang [6200 0079 0474], Li Yingshan [2621 7751 1472], Zhou Changhuai [0719 2490 3232], and Wang Pu [3769 2883] of the Institute of Atomic Energy, the Chinese Academy of Sciences. Manuscript received 3 Dec 84]

[Text]

Abstract: A KrF excimer laser pumped by relativistic electron beam of high intensity at a gas pressure up to 3.5 atm has been investigated. The experiment shows that for an Ar:Kr:F_2 = 89.6:10:0.4 mixture, the maximum energy is about 7.2 J and some KrF lines were observed.

Research on inertial confinement fusion and X-ray lasers using high power laser is at the forefront of the international scientific field. Neodymium glass lasers with a wavelength of 1.06μm have generally been used in these research, but it is worth noting that considerable progress has been made recently using KrF excimer lasers with a wavelength of 2484 Å in the ultraviolet. The energy coupling efficiency of the KrF excimer to the target material is high in the UV range and there is almost no preheating problem of the target center by superheated electrons. Besides, it is the only laser with a high efficiency (a few percent) in this wavelength range. As a result, researchers in the U.S., Japan, the UK, and the USSR are working on the KrF excimer laser.

There are a number of advantages in pumping the KrF laser with an electron beam. If a uniform electron beam can be obtained from a large area cathode, the longitudinal and transerve dimension of the stimulated gas can be large, leading to a large energy deposit and generating a high power laser.

The high current pulsed electron beam accelerator in the Beijing Institute of Atomic Energy has been in operation since 1982 and performing stably.[1] We have conducted some experimental research with this accelerator. We have recently developed a diode with a large area cathode and a large cross-section

electron beam was extracted from the diode to pump a KrF laser. Figure 1 shows the structure of the diode. The cathode is rectangular and made of brass, the anode is an aluminum foil of 50 μm thickness. The electron beam comes out of an 8.4x40 cm^2 window and is received by a charge collector to measure the total current emitted from the window. Preliminary results show that the performance of the diode is sensitive to the distance D_g between the electrodes and the surface geometry of the cathode. After tuning, the total current reached 50 kA and typical parameters are D_g = 2.0 cm. V_D = 600 kV, I_{out} = 46 kA, and the current density at peak output is 137 A/cm^2. The uniformity of the electron beam current density is examined by producing fluorescence on an organic glass plate and photographing the fluorescence. The uniformity of the laser intensity may be tested with acid test paper. Judging from the color distribution, the uniformity is still less than desired.

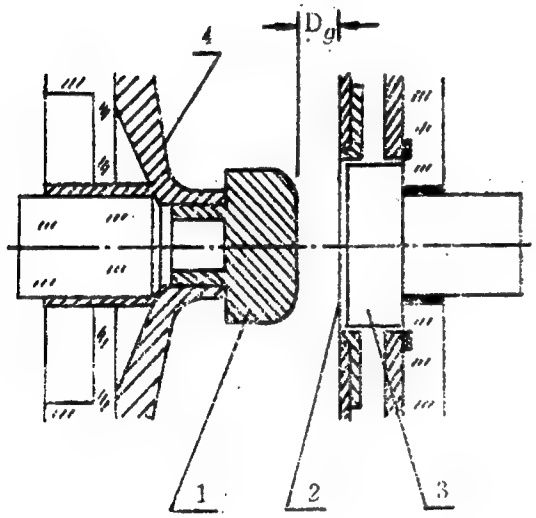

Fig. 1. Construction of the cold cathode diode and the current probe

Key:
1. Cathode
2. Anode foil
3. Charge collector
4. Cathode support

As shown in Fig. 2, the electron beam stimulates the working gas medium transversely. The volume pumped by the electron beam is 1.5 liter and the total pressure in the laser cavity is 1.5-3.5 atm. The ratio of the gas mixture is 0.4 percent F_2, 10 percent Kr, and the remainder is Ar and some trace amount of He. The cavity mirrors are a pair of polished flat quartz plates, and their transmissivity is 92 percent. The optical resonance cavity mirror also consists of a pair of flat quartz plates with reflectivities of 58 percent and 96 percent respectively and mode multiple films on a quartz substrate. The effective diameter of the mirrors are 70 mm and the two reflecting mirrors are separated by 62 cm. The cavity mirror and the window mirror are both adjusted to a position perpendicular to the optical axis of the laser during experiments.

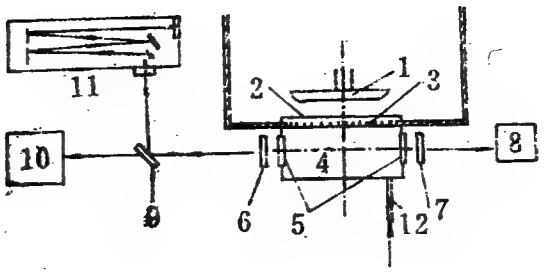

Fig. 2. KrF laser generation and testing apparatus

Key:
1. Cathode
2. Anode foil
3. Incident electron window with support
4. Laser cavity
5. ϕ 80x8 quartz
6. ϕ80x8 quartz lens (R = 58 percent)
7. ϕ80x8 quartz total reflecting mirror (R = 96 percent)
8. Photoelectric tube
9. Spectroscope (R = 4 percent)
10. Energy meter
11. Spectrophotometer
12. Vacuum and gas system

Figure 2 also shows the laser output parameters of the apparatus. A model JN-1 laser energy meter placed at one end of the output mirror measured the laser output energy to be about 6J and the maximum once reached 7.2 J. The spectral lines of the KrF laser and the fluorescence are photographed with a model WSP-1 flat grating spectrophotometer, see Fig. 3 and 4. The KrF spectral lines are confirmed using the iron spectrum as a standard. The width at half maximum of the KrF laser is found to be 5 Å and the fluorescence width is 30 Å (Fig. 5,6) using a model 3CS microdensitometer.

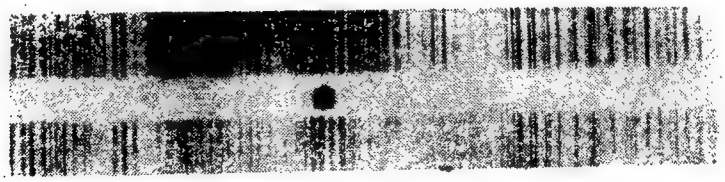

Fig. 3. The KrF laser spectrum. Center wavelength is 2482 Å. The top and the bottom rows are the standard spectrum of iron.

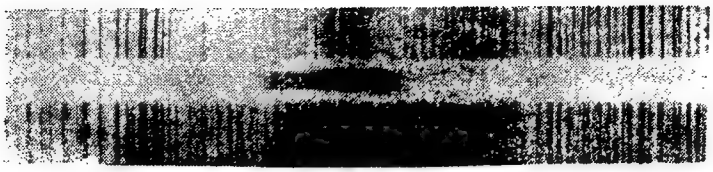

Fig. 4. The KrF fluorescence spectrum. The top and the bottom rows are the standard spectrum of iron.

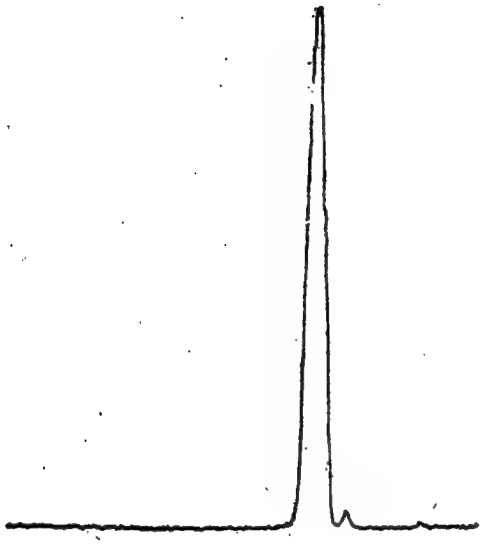

Fig. 5. Frequency distribution curve of the KrF laser line. The width at half maximum is 5 Å and the incident slit width of the spectrophotometer is 2 μm.

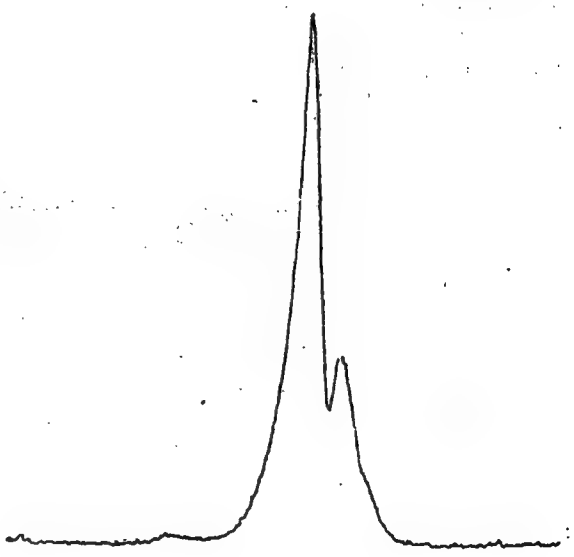

Fig. 6. Frequency distribution of the KrF fluorescence line. The width at half maximum is about 30 Å and the incident slit width of the spectrophotometer is 300 μm.

The Electronics Institute of the Chinese Academy of Sciences has earlier developed a KrF laser with NF_3, Kr, and Ar mixture and pumped transversely with an electron beam; the laser output energy[2] at 2484 Å was about 3 mJ. They have also built a long pulse large area high current electron beam source for transverse pumping and for controlled discharge pumping of high energy gas lasers. With the lasing of the controlled discharge pump X_{CCI}, a laser energy of 1 J was obtained in 1.9 liter of activated volume. Using this laser energy as the pumping source of a CO_2 laser, 360 J of laser energy[3] was obtained in a 7.85 liter volume. Since the discharge pump was controlled by the electron beam, the pulse width was quite large (1-3 μs). Such long pulse lasers are difficult to use in research on inertial confinement fusion and X-ray lasers. Figures 7-9 [not reproducible] show the voltage and current waveform of the electron beam and the KrF laser waveform generated by the electron beam pumping during a discharge of the accelerator. Figure 10 [not reproducible] shows the fluorescence waveform in a different run under the same electron beam parameters. The characteristics of the large area electron beam are found to be similar to those obtained at the Rutherford Laboratory in the UK.[4]

We have also studied the kinetics of pumping a KrF laser with an electron beam and obtained the dependence of the laser intensity on the electron beam density and the pressure of the gas mixture. The next step will be improving the laser quality and increasing the laser energy, studying the interaction of laser and materials, and exploring methods to supress the laser pulse width.

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APPLIED SCIENCES

APPLICATION OF RADIOGRAPHIC IMAGE ENHANCEMENT, SEGMENTATION

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 12, [Dec] 1984 pp 52-53

[Article by Wang Chengye [3769 2052 2814], Automation Institute of the Chinese Academy of Sciences Institute, and Xia Wei [1115 5633], Space Science and Technology Center of the Chinese Academy of Sciences]

[Text] Abstract: This paper introduces a method that enhances gamma ray images using a method that smooths partial images with whole information, and that uses the histogram guided convergence method to separate these images.

I. Preface

In keeping with the broader applications of radio-medical equipment, radiographic image (RI imaging) processing technology is currently attracting the attention of many scientists and technicians, as people are beginning to apply computers full scale in this field and are diligently advancing image restoration and enhancement technologies, while at the same time working to develop the technology for automatic diagnosis.

Because of penetration and spreading during the mobile process of gamma rays inside the human body, as well as changes in ventricle thickness and differences in measured accumulations, the projected images photographed by gamma ray machines are usually uneven and blurry and the grey between adjacent places changes only gradually. This is to say that because the grays in interior parts of the ventricle are not uniform, there is no clear division between different areas as the ventricle areas gradually shift to other different areas. This makes for great difficulties in reading images, and at the same time is an obstacle to furthering automatic processing, as for example in the geometric calculations for certain target locations.

The object of study in this paper is gamma ray imagery of the heart. The original images were provided by the Jishuitan Hospital Gamma Ray Laboratory, and were on black and white film as shot by the office of gamma photography. They had a graphic dimension of 380 mm, the instrument had a system definition of 4 mm, and the graphic edge diameter direction was equivalent to having 95 pixels.

We used two methods in this research: One was the method to enhance images by using whole information to smooth partial areas, to extend smoothing techniques to medical image enhancement; the other was the histogram peak guide convergence method for segmentation.

II. The Method of Using Overall Information To Smooth Partial Areas

Given that we have already input the histogram of an image as produced by statistics, for which see Figure A (omitted). We took a 3 x 3 window from the original figure, and let Z and Z', respectively, represent the grey area values of pixel ($f(x_0, y_0)$ in the window and its adjacent element, $f(x', y')$, and P and P' represent their probability.

Also, given that $S' = \frac{P' - P}{|Z' - Z|} > 0$, Z" is the grey value between Z and Z', P" is the corresponding probability, then $S'' = \frac{P'' - P}{|Z'' - Z|}$ if Z" exists, making $S''<S'/K$ (in which K is a parameter), in which case we would not use a pixel of the type $f(x',y')$ because this Z" exists, signifying that there is a depression in the histogram between Z and Z'. The points $f(x',y')$ adjacent to the point $f(x_0,y_0)$ selected with this method are all under the same histogram peak as $f(x_0,y_0)$, and moreover are pixels with a higher probability than $f(x_0,y_0)$. When we average this kind of pixel and use this average value to substitute for the grey value of central pixels, after repeated post processing, pixels of high probability in the original image will rapidly increase, and consequently make the original peaks in the histogram steeper, tending to approach the shape of sharp peaks. This kind of change means that the objects or areas corresponding to those sharp peaks abruptly become uniform, which results in enhancement.

III. The Method for Histogram Peak Value Segmentation

1. Automatic selection of histogram peak values:

The grey characteristics of various objects in images reflected by histogram peak values, under set conditions, represent the average grey level of objects, and peak values can be obtained by manually analyzing grey histograms of a full range image, or can also be achieved automatically via a computer. This paper uses the latter method, the basic procedure of which is as follows:

a. Preprocessing: In order to reduce the noise effect on automatic peak search calculations, we first undertook preprocessing using a histogram smoothing method on images, smoothing away false peaks and burrs produced through the effects of noise. Smoothing substitutes the average probability of the adjacent three pixels for the central point, as in: $[prob(g-1)+prob(g)+prob(g+1)]/3$. In the formula, prob(g) represents the probability produced by pixels where histogram grey values are g.

b. Extracting the histogram peak and valley points: We found the gradient of the histogram at each grey step after smoothing, determined as peak and valley points (points of inflection) the gradient symbol generated changes

(i.e., signum generated changes), and also sequentially arranged the peak and valley points according to the size of the probability for each peak and valley point.

c. Automatic peak selection: Based on image characteristics and practical requirements we selected the least distance (Dis) between peak points and the number (N) of the peak value, compared the distances between the histogram peak points as selected with the least distance given, and took as the central peak value m_i, i=1, ...n each peak value greater than the least distance between peak values.

Finally, we arranged according to size the probabilities of the peak values as selected according to given distances, we took the grey values corresponding to the front N peak values for the highest probabilities among those selected, and we dropped the remaining peak values.

2. Classify according to the criterion of the least distance:

With the average value M_1 of the classes obtained from the section above as the center, we classified each pixel with the small distance calculation method.

The decisive formula was: $D_i S_i = |X - M_i|$, where

if $D_i S_i < D_j S_j \quad j \neq i$, then $x \in \omega_i$.

3. Relaxation method post processing:

The probability relaxation method used here iteratively renews the probability of pixel classes in given images.

In the (K+1) iteration, the formula for calculating $P_i(\lambda)$ is:

$$P_i^{(K+1)}(\lambda) = \frac{P_i^{(K)}(\lambda)[1+q_i^{(K)}(\lambda)]}{\sum_{\lambda' \in \Lambda} P_i^{(K)}(\lambda)[1+q_i^{K}(\lambda)]} \tag{1}$$

where $$q_i^{(K)}(\lambda) = \sum_j dij \sum_{\lambda' \in \Lambda} P_j^{(K)}(\lambda') r_{ij}(\lambda, \lambda')$$

dij is the weighted value of adjacent points, the sum being 1. r_{ij} is the compatibility coefficient [correlation coefficient] for point i class λ and class λ' of adjacent point j.

For the compatibility coefficient we used two formulae: 1) like enhancement coefficient: if the classes of point i and point j are the same, then take $r_{ij} = 1$, if the classes of point i and point j are not the same, then take $r_{ij} = 0$; 2) the Hummel and Zucker coefficient, the expression of which is:

$$r_{ij}(\lambda, \lambda') = \frac{\sum[P_i(\lambda) - \bar{P}(\lambda)][P_j(\lambda') - \bar{P}(\lambda')]}{\sigma(\lambda)\sigma(\lambda')}$$

in which, $P_i(\lambda)$ is the estimated value of initial probability when the class of point i is λ, $\bar{P}(\lambda)$ is the average value of the probability of $P(\lambda)$ for any point, and where $\sigma(\lambda)$ is the standard deviation for $P(\lambda)$. Thus, $P_j(\lambda')$, $\bar{P}(\lambda')$, and $\sigma(\lambda')$ are the respective corresponding parameters for points j adjacent to i.

(Editor's note: the figure accompanying this article was not clear, so it was omitted)

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APPLIED SCIENCES

IRON AND STEELMAKING WITH PLASMA

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[Text] Plasma technologies were in use as early as the 1940's in the industrial production of acetylene in Germany, and they continue to be used up to the present day.[1] Since then, other nations have studied the utilization of plasma technologies for metal cutting, metal spray coating, extractive metallurgy,[2-4] coal gassification[5-6] and recovery of trace amounts of alloy elements in coal,[7] steelmaking-waste steel melting, production of high alloy steel,[8-13] ironmaking-blast furnaces,[14-16] direct reduction of iron and iron alloys,[17-28] blast cupolas[29-30] and plasma remelting,[31] and in other areas on a wide scale. Through intermediate experiments, some already have become industrial production equipment. This article provides a brief introduction to the situation in plasma iron and steelmaking.

Plasma iron and steelmaking uses a smelting method that converts the thermal energy in electrical power to gas, and can be called a type of electrometallurgy. For this reason, plasma iron and steelmaking first of all requires consideration of the question of electricity supply capacity and the price of electrical energy. It has attracted a great deal of attention from iron and steel workers in some regions and nations with abundant electric power resources. Research and production work in this area now is unfolding.

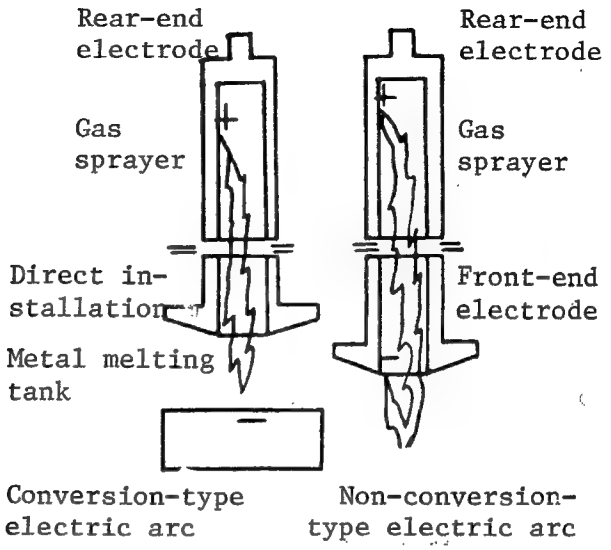
I. Plasma Technologies

A gas at room temperature is composed of many molecules, each molecule usually being formed from two or more atoms. The molecules of the gas decompose into single elements when it is heated to around 2,000°C. When heated to 3,000° to 3,500°C, the atoms lose some of their electorns and it becomes an ionized gas, a plasma gas with a high heat content. This function can be completed using a plasma gun (also called a producer, nozzle or burn nozzle).

Current plasma guns mainly use either conversion-type electric arcs or non-conversion-type electric arcs (see Figure 1), the conversion-type electric arc uses one electrode running toward the metal melting tank. Non-conversion-type electric arc methods use two electrodes, both of them inside the plasma

gun. The electric arc "rebounds" inside the gun. A small amount of air or gas is ionized by being sprayed into it and a high-temperature plasma flame is emitted from the end of the gun. This basic principle can be used for smelting in iron and steel metallurgy.

Figure 1. Illustration of the Principles of a Plasma Gun



II. Plasma Steelmaking

With assistance from the Soviet Union, the East German Special Steel Mill put a 15-ton conversion-type electric arc DC plasma steelmaking furnace (plasma furnace) into operation in 1973 and a similar 40-ton furnace into operation in 1977. In 1979, the Austrian Steel Federation purchased special rights for the East German plasma furnace and built a 45-ton plasma steelmaking furnace at the Linz mill to replace two 25-ton arc furnaces and one 12-ton induction furnace. Investments totalled 100 million Austrian shillings (3.7 million English pounds) and it went into operation in October 1983. Annual steel output is 130,000 to 180,000 tons. The West German Krupp Company first built a 10-ton three-phase plasma steelmaking furnace at its Siegen mill and later built a 50-ton three-phase plasma furnace.

The East German plasma furnaces basically are electric arc furnaces. All use metal electrodes instead of carbon electrodes and a plasma arc instead of an electric arc. They are different in that the plasma gun extends downward along the wall of the furnace and directly into the surface of the melting tank. The tungsten electrode [cathode] is located in the center of the gun and the anode is located in the center of the bottom of the furnace. The plasma arc between the electrodes ignites the fuel that heats the melting tank and melts the waste steel. The location and orientation of the plasma gun can be changed using hydraulic systems.

The longest electric arc length is determined by the voltage and by the type of gas chosen as the process gas. Argon or a gaseous mixture of argon and nitrogen were selected to assure that the length of the electric arc is sufficient for melting the waste steel.

1. Metallurgical characteristics.

Plasma furnaces can achieve all the operational techniques of steelmaking and steel smelting, and can be even better.

a. Sulfur content. The slag temperature is relatively high and desulfurization easily reaches a content of 0.010 percent.

b. Dephosphorization. There is an obvious improvement in dephosphorization. The waste steel and slag load has a phosphorous content of 0.030 to 0.040 percent and the final phosphorous content can reach 0.006 to 0.008 percent.

c. Nitrogen content. If argo gas is used exclusively during the smelting period, the nitrogen content of low-alloy structural steel is 80 to 100 ppm. The figure for chromium steel made of chromium and iron is 150 to 250 ppm. If nitrogen-containing austenite is being smelted, an argon-nitrogen gas mixture can be used, with nitrogen accounting for two-thirds the gas atmosphere.

d. Hydrogen content. If the furnace load is not preheated and dried, the hydrogen content is 2 to 5 ppm. If the furnace load is preheated, the hydrogen content is 1.5 to 2.0 ppm.

e. Contaminants (oxides, sulfides) are much lower than in regular electric arc furnaces.

Current production of low, medium and high-alloy steel, nickel steel and nickel-based alloys has proven that there is a high recovery rate for alloy elements (Table 1).

Table 1. Recovery Rate for Alloy Elements in Medium and High Alloy Steel, in Percent[11,12]

Alloy	Smelting Method			Alloy	Smelting Method		
	Plasma gun	EF/AOD	EF			EF/AOD	EF
Cr	98~100	97	94	W	97~98	96,97	85~90
Ni	99~100	98	98	V	95~97	93~97	83~85
Mo	98~100	97	94~95	Ti	75~88	65~70	45~65
Mn	97~98	94	90~94	Al	68~85	—	65~75
Si	96~100	96~100	88~91	B	98~100	—	—
Nb	98~100	98~100	74~77	Fe	98~99	96~98	94~96

In terms of full melting times, the actual full melting time for waste steel with a density of 1.3 to 2 tons/m^3 is 70 to 90 minutes.

With regular maintenance, the electrodes in the plasma gun and at the furnace bottom have a total life of 2,000 hours. Retamping the furnace bottom after 150 firings increased the life of the furnace bottom electrode to 500 to 700

firings. Chromium-magnesium bricks are used for the furnace sleeve, and the furnace bottom is made of tamped magnesium sand. The temperature at the surface of the furnace sleeve reaches 1,800°C during operation. The parameters of a plasma furnace are shown in Table 2.

Table 2. Parameters of a Plasma Steelmaking Furnace

	P15	P40	P45 (奥钢联)
公称容量, t (1)	15	40	45
炉子直径, mm (2)	3900	5800	5800
直流电最大容量, kW (3)	10,000	20,000	36,000
最大电压, V (4)	700	700	
电网电压, kV (5)	15	15	
供电频率, Hz (6)	50(60)	50(60)	
熔清能力, tph (7)	8~12	20~25	
熔清能耗, kWh (8)	450~550	450~500	
氩消耗, Nm^3/h (9)	15	30	
耐材消耗, kg/t (10)	16/7	16/7	
噪声标准, dB (11)	80	80	
等离子枪数, 支 (12)	3	4	4(7~8MW)

Key:

1. Nominal capacity, tons
2. Furnace diameter, mm
3. Maximum DC Capacity, kW
4. Maximum voltage, volts
5. Grid voltage, kV
6. Power supply frequency, kHz
7. Full melting capacity, tph
8. Full melting energy consumption, kWh
9. Argon consumption, Nm^3/hour
10. Resistant materials consumption, kg/t
11. Noise standard, dB
12. Number of plasma guns

2. Advantages of plasma steelmaking:

a. There is almost no wear on the tungsten cathodes, and the production expenses for the entire plasma gun and furnace-bottom electrode are less than 25 Austrian shillings per ton of steel.

b. Furnace sealing. In an inert gas atmosphere, the plasma gas maintains an extremely low normal pressure and eliminates oxidation. This improves the recovery rate of the metal load and reduces the amount of slag.

c. Low environmental pollution (small amounts of soot and waste gas, and noise generally is less than 85 db or so).

d. There are minimal effects on electricity supply lines and no need for short-circuiting to ignite the electric arc.

e. Electricity consumption per ton of steel generally is similar to that for regular electric furnaces.

f. Consumption of fire-resistant materials is similar to regular electric furnaces.

III. Plasma Ironmaking

New techniques for ironmaking using a plasma reduction method followed plasma steelmaking, and plasma iron alloys (manganese steel) have been produced industrially. Plasma blast furnace ironmaking still is being tested and plasma blast cupolas have been transformed for production of cast iron.

1. A new family of plasma reduction methods. The Swedish Bearing Steel Company (SKF) has successfully researched such members of the plasma ironmaking family as Plasmared, Plasmasmelt, Plasmadust and Plasmachrome.

The plasma guns used in the plasma reduction method can be of two types, conversion-type electric arc and non-conversion type electric arc. The Bearing Steel Company uses the non-conversion-type. When the power of the plasma gun was increased from 3 MW to the rather substantial 6 MW in 1983, it could control DC electricity supply in the silicon grid and obtained excellent results. The technique for using electrical energy to convert the gas into thermal energy is shown in Figures 2a and 2b. The principles of the plasma gun are shown in Figure 3.

Figure 2a. Principles of the SKF Plasma Gun[36]

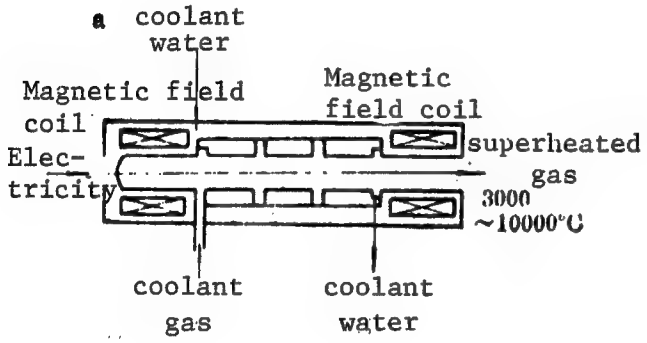


Figure 2b. Illustration of Plasma Gun Techniques for Conversion of Electricity into Thermal Energy[22]

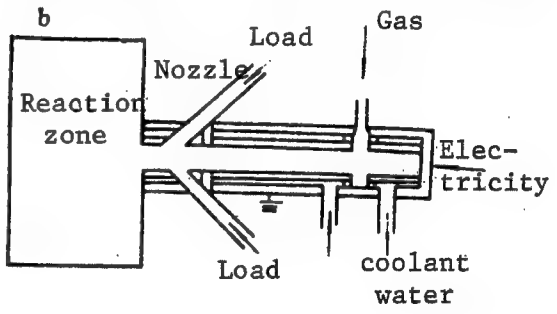
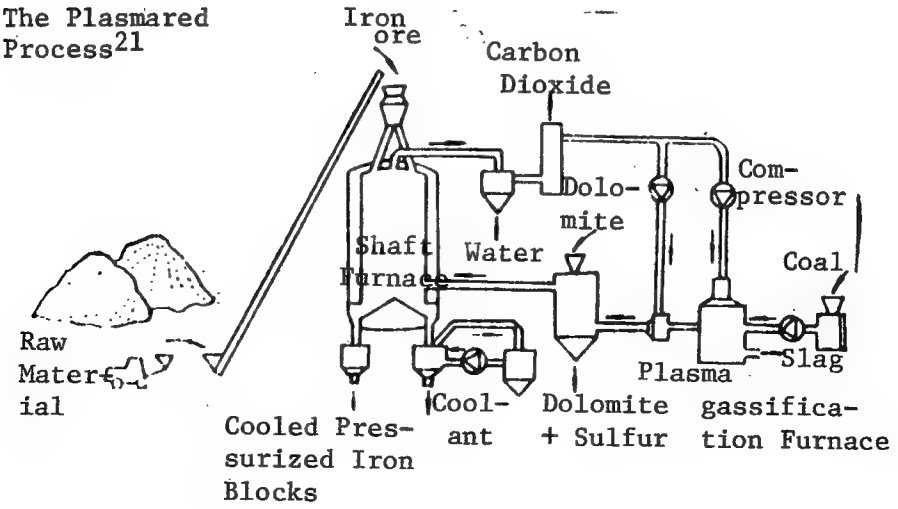


Figure 3. The Plasmared Process[21]

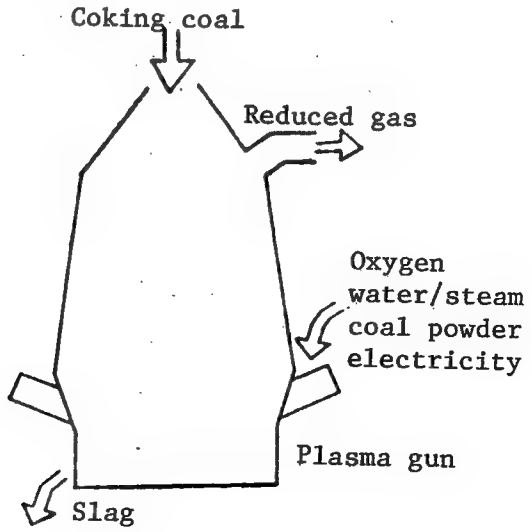


The plasma gun used by SKF has a layout of separate front and rear water-cooled copper electrodes. During startup, a long electric arc is formed gradually between the two electrodes and is sent into the gas in a circular line. The gas around the electric arc is ionized and absorbs a large amount of heat, forming a conductive super-heated gas around part of the electrodes. The temperature of the thermal energy converted from electrical power drops a great deal to around 5,700°C, a conversion efficiency of around 85 percent. In this way, the use of a plasma gun can transmit the heat into the reaction zone. During production (Figure 2b), the thermal energy of waste gas enters the shaft furnace after it comes out of the shaft furnace, is cooled, purified and compressed, and acts as a process gas after it is sent into the plasma gun for conversion. Some of the process gas serves as a carrier gas for the furnace materials (iron ore or soot, slag-forming materials, coal) and is blown together with them into the reaction zone for reduction and melting.

a. The plasmared method. The Bearing Steel Company transformed the Wiberg reduction method equipment that had gone into production at Hofors in 1951 into a Plasmared installation in 1980 (Figure 3). The original coking coal gassification furnace was changed into a plasma gassification furnace and the reduced gas it produced was supplied to a shaft furnace for use in iron ore reduction. After going into operation in 1981, direct reduction of crude iron increased from 25,000 tons to 50,000 tons. Liquified petroleum gas first was used as a fuel. It was changed over to using coal slurry as a fuel for gassification in May of 1982. The direction reduction crude iron that is produced is used in steelmaking. A test using 100 percent block ore was completed recently and the situation was excellent.

(1) Plasma gassifier furnace (Figure 4). The coal powder blown into the plasma reaction zone has a temperature of about 4,000 C. It first of all is gassified in the coking coal bed cavity reaction zone and then forms a permanent high-temperature heat-resistant layer that prevents the high temperatures from burning the furnace sleeve. It passes across the superheated coking coal bed as crude coal gas. The CO and steam contents of the goal gas are much lower than in normal coal gassification. The crude coal gas that is produced is mixed with the purified and cooled coal gas. After going into a dolomite furnace for desulfurization, the reduced gas (800 to 850 C) enters the shaft furnace and reduces the iron ore, producing direct reduction crude iron.

Figure 4. A Plasma Gassification Furnace[21]



The use of steam as an oxidizing agent for coal gassification consumes large amounts of electricity. The result has been a recent switchover to using oxygen and steam and oxidizing agents (Figure 4), which greatly reduces electricity consumption. The large amount of heat needed for the gassification process is supplied by the heat in the heat-emitting reaction zone. The plasma gun supplies a small amount of the heat and maintains a normal gassification temperature to guarantee complete gassification and obtain high-quality reduced gas.

A plasma gun greatly accelerates the reaction speed and controls the gassification reaction and slag formation reaction rather well. For this reason, it is not restricted by the type of coal, ash content and ash melting point.

Coking coal consumption accounts for 20 percent of total coal consumption.

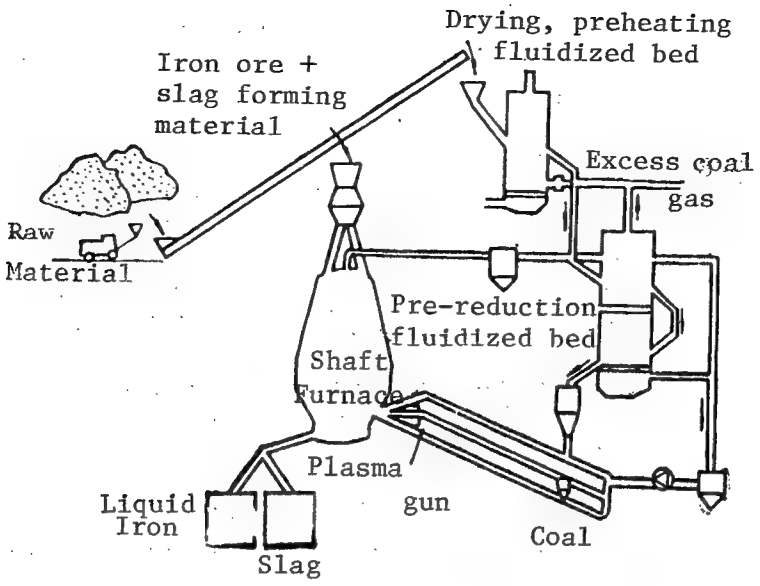
The gassification process is carried out at high temperatures, which can avoid the production of tar, phenol and polycyclic aromatic hydrocarbons. This means that no additional purification equipment is needed.

b. The plasmasmelt method. The goal of research on pre-reduction and melting of iron ore is to search for methods of liquid iron production that are more economical than blast furnaces. The primary advantage of this method is the lower investments needed than for blast furnaces. The investment for a blast furnace that produces 2 million tons of pig iron annually is $720 million. The investment for a plasmamelt furnace with annual output of 250,000 tons is $38 million. Production costs are 16 percent lower than for blast furnaces, which can imporve the competitive abilities of small iron and steel mills. Output can be increased three-fold is a blast furnace is changed over to a plasmamelt furnace.

The Plasmamelt process (Figure 5). The clay ore in the fluidized bed that is pre-heated and dried by the coal gas at the top of the furnace converts the 50 to 60 percent of the iron ore into pre-reduced ore (700°C). Then, some of the coal gas at the top of the furnace is used as a carrier to blow the pre-reduced ore, slag-forming material and powdered coal together into the plasma gun and flow downward into the coking coal cavity reduction and melting region in the shaft furnace (see Figure 2b). Because the region has strong heat absorption, the high temperatures of the plasma arc drop quickly from 3,000" to 5,000°C down to 2,000° to 2,300°C. The iron ore is melted quickly and collects in the lower part at the bottom of the furnace, and is drained out at regular intervals. The liquid iron has similar constituents to liquid iron from a blast furnace, but the sulfur content is lower, around 0.01 to 0.015 percent. Electricity consumption is 1,120 kWH per ton of iron. If the sprayed coal is increased to 440 kg, more surplus coal gas can be produced, which lowers electricity consumption.

The coking coal in the shaft furnace is not used as a reducing agent, but instead forms a permanent reaction zone that can resist temperatures as high as 2,300° to 3,300°C. This protects the furnace sleeve and provides a balanced carbon content for the liquid iron.

Figure 5. The Plasmamelt Method[21]



A new test of large-scale equipment has been completed recently (Figure 6). The ore is pre-heated and dried in the fluidized bed in the upper left part of the figure. The ore is pre-reduced in the fluidized bed at the lower right. The pre-reduction system is 18 m in height. Industrial equipment also is of this size. Greater capacity is possible merely by increasing the diameter of the fluidized bed.

The test used magnatite and hematite and had a pre-reduction capacity of 700 to 1,200 kg of pure ore powder per hour. The particle diameter of the ore powder was 2 mm, and it may be possible to reach 5 mm at an industrial scale.

The reduction rate of the fluidized bed is generally 50 to 60 percent, which is equivalent to a metallization rate of 25 to 40 percent. Such a low reduction rate facilitates fluidized bed operation. A higher reduction rate could cause bonding.

c. Plasmadust. The Bearing Steel Company applied the research experience on Plasmamelt to recover the chromium, nickel, molybdenum and other precious heavy metals in the metallic oxide in the electric furnace bag dust at the Special Steel Mill and successfully studied the Plasmadust Method. The Scandust Company completed facilities at Landskrona in 1982 with an annual soot processing capacity of 70,000 tons. It produces 35,000 tons of liquid iron a year and even recovers zinc. It went into operation during the spring of 1984. The experimental shaft furnace used a 1.5 MW plasma gun in a technical process outlined in Figure 7. The furnace load used process gas as a carrier that is blown into the plasma gun and flows into the coking coal cavity reaction zone at the bottom of the shaft furnace. The oxides and reduction agent undergo a heat-absorbing reaction, the heat required by the reaction being supplied by the plasma gas (Figure 2b). Actually, all of the oxides in the load are reduced at the same time and melt to become liquid iron. The

The liquid iron is drained out once every 2 hours. The zinc and lead that are released pass over the coking coal bed into the waste gas. The waste gas leaves the shaft furnace and passes through a condenser, where it is cooled from 1,200°C to 500°C. The zinc comes out of the condenser and is cast into zince ingots.

d. Plasmachrome. On the basis of the Plasmamelt technology, the Bearing Steel Company tried production of chromium steel and high coal chromium steel of various contents. The chromium oxide did not use gas reduction, so there is no pre-reduction stage. The chromium ore and coal powder are blown together directly into the shaft furnace. The results of the experiment were a fairly high level of chromium recovery and low sulfur content.

Austria put a 50,000 ton/year capacity plasma furnace into operation in 1983. A conversion-type electric arc plasma gun with a power of 8 MW was used. The power-supply equipment capacity was 10.4 MW.

To reduce imports of expensive waste steel, Sweden plans to construct a 150,000 to 200,000 ton/year Plasmared facility in Stockholm for production of high-quality reduced iron, and it is building a 78,000-ton per year Plasmachrome facility at Malmo for production of high-coal chromium iron. The investment for both totalled 700 million kronen, equal to $90 million. The thermal energy of the surplus coal gas produced annually in the former plant is 600 GWh, which is equivalent to the energy in 80,000 tons of coal. The destruction of all organic material by the high temperatures of the plasma gun reduced the amount of sulfur emitted into the atmosphere by 800 tons.

The thermal energy of the surplus coal gas produced annually in the second plant reaches 100 GWh. An extremely small amount of sulfur is scattered into the atmosphere. Regular chromium iron production methods would send 300 tons of sulfur into the air each year. An additional 65 GWh of thermal energy in the coal gas was produced each year using the Plasmadust method, equivalent to the energy in 6,500 m^3 of petroleum. Moreover, the utilization of this surplus heat can lead to a substantial reduction in the amount of electricity consumed and has additional environmental protection benefits.

1. Plasma blast furnace ironmaking--PIROGAS Method (Plasma Injection of Reducing Overheated Gas). The Belgian Centre de Recherce Metalurgique (CRM) performed several tests on a plasma gun in a small 2.5 m high blast furnace with a diameter of 0.300 mm in the furnace cylinder with microcomputer control. The air is replaced with spray-blown superheated reduced gas, which causes the hot wind temperature to reach 1,800°C. The tests show that the coke ratio can be 100 kg or less.

After this, an industrial test of a 3.5 MW plasma gun installed in a wind gap of a 4.6 m diameter furnace cylinder in a producing blast furnace was carried out (Figure 8). The results were that the coke ratio could be lowered by 85 percent (the coke ratio was halved in the test of the SKF blast furnace). The plasma gun of the blast furnace is easy to operate and does not interfere with the power grid. Experiments on the installation of plasma guns on eight wind gaps are continuing on this foundation. The Japanese Steel Pipe Company has tested a plasma gun installed in a blast furnace at its (Shandao) mill.

Figure 6. Experimental Fluidized Bed Installation[21]

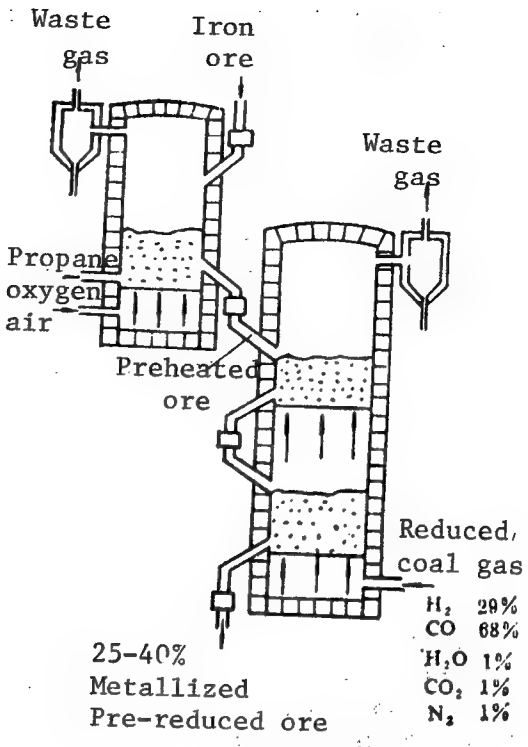


Figure 7. The Plasmadust Method[19]

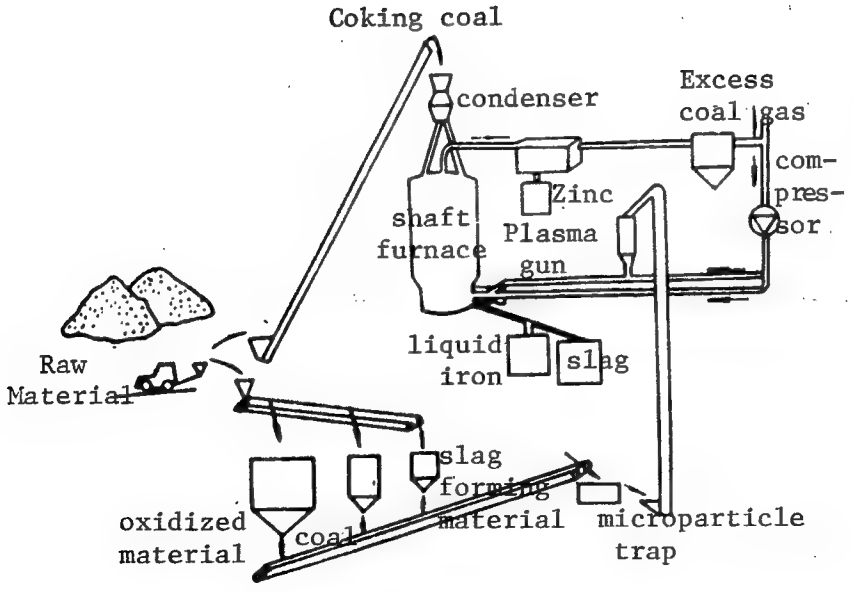
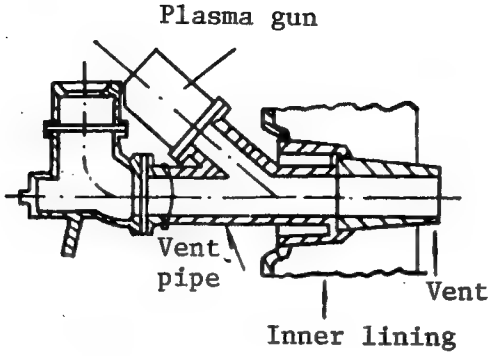


Figure 8. Illustration of the Installation of a Plasma Gun in a Blast Furnace Vent[16]



3. Plasma blast cupola. The Plasma Technologies Research Center of the U.S. Westinghouse Electric Company and the General Motors Corporation worked jointly to develop a plan for using plasma technologies in a blast cupola. The Modern Equipment Company is engaged in conversion of an existing 60 ton/hour blast cupola into a plasma blast cupola. The low-cost loose iron cutting fragments in the load (without processing or hammering into blocks) can reach 70 percent. An estimated $19.60 will be saved per ton of pig iron ($12.38 of which will be from utilization of unprocessed loose waste iron fragments), and coke consumption will be reduced from 146 kg to 46 kg. Each ton of cast iron consumes 395 kWh of electricity.

The non-conversion-type electric arc plasma gun described above was manufactured by the U.S. Westinghouse Electric Company.

4. The advantages of plasma ironmaking.

(1) Plasma blast furnace ironmaking can greatly reduce the coke ratio.

(2) In using the plasma reduction method for ironmaking:

a. Powdered ore is substituted for block ore or sintered ore.

b. Inferior coal is substituted for coking coal.

c. Iron alloys can be produced.

d. Extremely small amounts of sulfur are discharged into the atmosphere.

e. A plasma gun for chromium ore smelting can be used to produce stainless steel.

Moreover, there are many other conversion-type electric arc plasma furnaces that are being tested for production of direct reduction crude iron and iron alloys.

The Raleigh Plasma Energy Company in North Carolina, U.S., is doing research on plasma applications in the iron and steel industry and in other areas.

It has been stated that the Soviet Union has been using plasma for remelting and production of high-quality electroslag remelted steel for bearing steel. Plasma furnaces will be built to replace electric furnaces in the Soviet Union and the U.S. before the end of this century.

The southwest, northwest and south-central regions of China have abundant hydroelectric power resources. In regions with completed or to-be-completed hydropower stations, consideration can be given to technical transformation of existing iron and steel mills as well as to the construction of plasma furnaces. Or, when making technical transformations in special steel mills and iron alloy mills, consideration can be given to whether or not the original electrical equipment can be used for the rebuilding of an electric furnace or an iron alloy furnace to create the conditions for the development of plasma iron and steelmaking in China.

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APPLIED SCIENCES

INTERFACING MODERN SERIAL DISPLAY TO DJS-130

Shanghai DIANZI JISHU [ELECTRONIC TECHNOLOGY] in Chinese No 8, 20 Aug 84 pp 9-11

[Article by Chen Wei [7115 5524]: "DJS-130 Computer Users Adapt Serial Display Terminals"]

[Text] In the 1970's, the DJS-130 computer system was connected to the domestically produced parallel character display, but because both the capability and price of this equipment was low, many users did not install it, and the average user used either a teletype or a DZM-180 KSR printer as a controller for the computer. When using a teletype for a controller, the 130 computer must do a code conversion from 5 to 8 units or from 8 to 5 units, corresponding to its input or output, which consequently greatly reduces the working speed of the system. When there was no international ASCII code characters corresponding to the input or output, two five-unit characters had to be put together to substitute for it, which complicated operations and made hard copy difficult to read. In addition to this, using teletypes greatly increases the clamor in the operations room, and their mechanical structure is quite complicated, with many special components, so down time was high, which was a factor in increasing the unreliability of the entire system. Using the DZM-180 KSR as the controller for man-machine relations with the DJS-130, even if it is convenient to operate and there is little noise, when using it as the primary I/O device in RDOS one generates a lot of hard copy that is not worth saving, and long use will create much waste.

At present, there are many plants and companies producing or selling character terminals with EIA (United States Electronics Industries Association) RS-232C serial interfaces, which have a stable performance and are inexpensive. Using them as controllers for the DJS-130 computer, one can avoid the problems of operational complications, high noise level, and a high rate of down time. Using one as the primary or secondary I/O device in RDOS is both economical and convenient.

I. Chief Functions of the Serial Interface

The key to matching serial character displays and the DJS-130 computer is in interface design. This interface can not only have the controlling functions under DJS-130 program interrupts, but can do data conversion between serial

and parallel, as well as conversion from EIA signal levels to TTL logic levels.

Character terminals with the RS-232C interface exchange information with the computer in serial asynchronous mode. In serial asynchronous data flow, starting bits are generally used to indicate the beginning of a character, stop bits are used to indicate the end of a character, which structure forms a frame. Figure 1 shows an ASCII code serial data pulse within an 11 bit frame. Because computers use parallel mode to transfer information, when the display sends information to the computer, the interface must convert the asynchronous serial format to the parallel format, and must also eliminate the start and stop bits in each character; when the display accepts data output by the computer it must first convert the parallel format to the serial format, and must as well add start, parity, and stop bits to each character. Each level of signal in an RS-232C interface conforms to EIA standards, where below -3 volts is logic level 1, and above 3 volts is logic level 0. This is not compatible with TTL logic levels, and therefore when the character terminal is inputting and outputting it must do a level conversion at the interface. From the point of view of circuit design, it is very convenient if the general asynchronous receiver transmitter UART, MC1489 receiver, and MC1488 driver are used for serial and parallel conversion and level conversion. But this requires the user to design and make his own 450 X 450 mm pc board, which would be difficult for the average user or plant or company to do. A rather simpler method is to refit the secondary I/O device circuit board in the DJS-130 multiplex communications controller as a serial interface board for the character display.

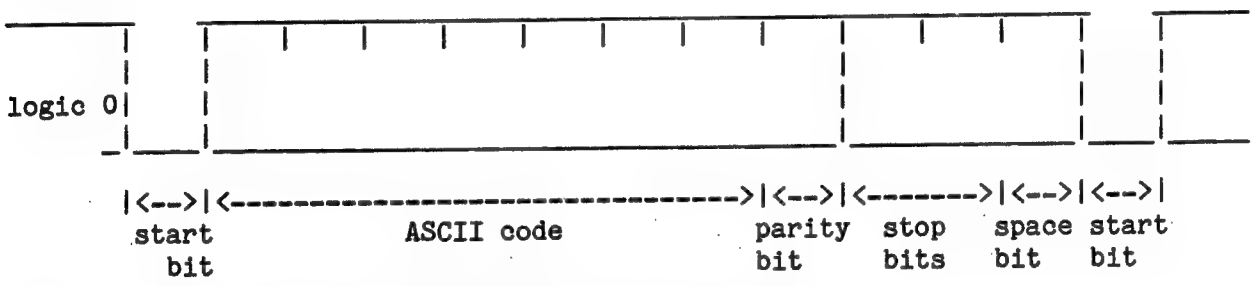


Figure 1 Asynchronous Transmission of Serial Data

II. Particulars for Adapting the Interface

We use the second I/O pc board in the multiplex communications controller produced by the Weifang Computer Plant in Shandong for the refitting, and connect a model ADM-5 character terminal that complies with the EIA RS-232C serial standards to the DJS-130 computer system. The terminal acts as the controller for the system and has operated for nearly a year without being down. The model ADM-5 interactive display, manufactured by the American Lear Sieglar Company and sold by the Fujian Television Plant, has better performance than the ADM-3A. The computer interface (modem) of the ADM-5 is

either EIA RS-232C or 20 mA current loop, permitting an RS-232C extension interface, as well.

The second I/O interface logic is similar to the DJS-130 basic peripheral teleprinter interface, so we will here only discuss the different parts and changes to be made to fit to the character display.

1. Common logic. Aside from the interrupt queue lines, the input gate circuits in the output bus lines, the common equipment code composite line, and the filter circuit for the controller signal, all part of the 130 computer's program interrupt mode basic interface, there are also a baud rate generation circuit and a 5 to 8 bit system selection circuit, as well as modifications to the signal for overall clearing of peripherals, equipment code input, and the select line. In the refitting, it will work if the ICs used solely by the multiplex communication controller in the common logic of the original pc board, as for example the #44, #55, #57, #76, are given an empty substitution.

a. Baud rate generation circuit. This circuit is a multilevel frequency division circuit composite made up of an 18.5 kHz crystal oscillator and a D flip-flop, as shown in figure 2. The crystal oscillator is an ordinary two-stage transistor regenerative oscillator circuit. CF_{07} and CF_{08} in the frequency divider are used by the "S" terminal in the D flip-flop to form a three-frequency divider circuit, which provides 200, 100, and 50 baud synchronous signals, and each level of the rest being a two-frequency division circuit, providing 150 and 75 baud synchronous signals. In addition to this, and if necessary, if you make short connections of the "1" terminals (lead 12) of CF_{02}, CF_{01}, and CF_{00}, you can get 300, 600, and 1200 baud clock signals, respectively. From the #36-10 lead you can even get a 2400 baud synchronous signal. These various baud rates may be selected by the user at will.

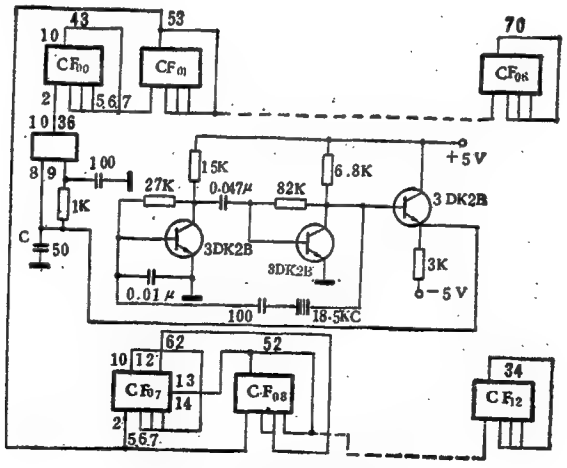


图 2 波特率产生电路

Figure 2 Baud Rate Generation Circuit

b. The 5 to 8 unit code system select circuit. The second I/O interface provides a 5 to 8 unit code system select circuit for selection by the user, which makes it convenient for connecting different 5 and 8 unit code equipment. XZ_5 and XZ_8 are the system select signals, and when selecting the 8 unit equipment, XZ_5 is low and XZ_8 is high; when selecting 5 unit equipment, the signal levels of XZ_5 and XZ_8 are reversed. The selection of either high or low in each is effected by differing connections of the short connections W_1 and W_2, as shown in figure 3. When adapting the ADM-5, use the short connection W_1, ground the XZ_5 signal, and allow the switchover to be the 8 unit character display interface.

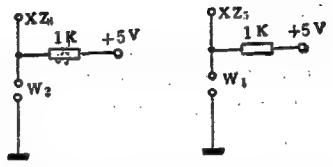
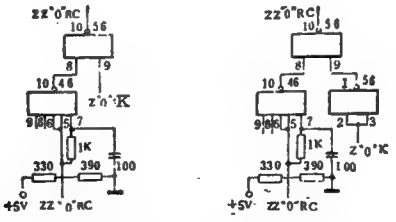


图3 5-8单位制式选择电路

Figure 3 5-8 Unit System Select Circuit

c. Altering the signal for general clearing of peripherals. In the common logic circuit schematic for the multiplex communications controller, there is an error in the logic of the signal to clear peripherals (ZZ"0"RC), which needs modification, as in figure 4. In the original design, as long as the reset signal (Z"0"K) on the host computer controller board is not added, the #56-9 will be low, and even if #56-10 is high, it will be as if the ZZ"0"RC signal is always in its initial state, which consequently causes the controller flip-flop in the display input output interface to be always set in its initial state, which in turn leads to improper working by the interface. Therefore, after inverting Z"0"K through a NOT gate, reconnect #56-9. Only in this way can the ZZ"0"RC signal output by #56-10 play its normal role. For the standby and NOT gates made up of the 1,2, and 3 leads of chip #56 that we borrowed, invert the Z"0"K, and reconnect #56-9, allowing normal operation for this portion of the circuit.



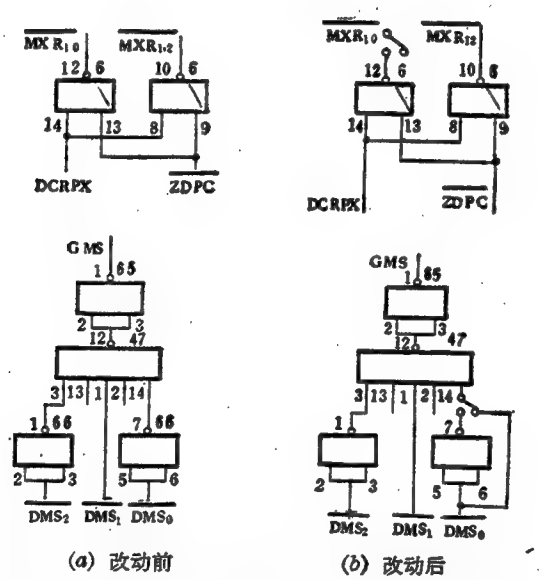
(a) 改正前 (b) 改正后

图4 总清外部设备信号的更改

(a) before correction (b) after correction

Figure 4 Modification to the Signal to Clear Peripherals

d. The first and second I/O equipment code selection switch. Rules for the DJS-130 computer stipulate that the first I/O equipment code be 10/11, and the second, including the character display, be 50/51. To ensure that the display terminal fitted can be both for background use in the first I/O port under RDOS and in the second I/O port for foreground use, we have added selection switches for two equipment codes. The distinction between the first and second input/output equipment codes is simply in whether the logic level of the DMS_0 is "0" or "1". If this bit code level is logic 0, then the equipment code is 10/11, and otherwise it is 50/51. At the same time, if MXR_{10} in the equipment code input line is logic "0", then the input code is 10; if the logic level is 1, then the input equipment is 50. We made a modification in the common equipment code composite circuit and equipment code input circuit of the interface, shown in figure 5, where the switch selected in the diagram is a double-bladed, double-throw manual switch. If the switch is moved to the right, DMS_0 does not pass through #66-5,6,7 and the NOT gate, but connects directly with #47-14, MXR_{10} is cut off, which selects the first I/O equipment code; if the switch is moved left, DMS_0 passes through the NOT gate and is inverted, after which it goes to #47-14, MXR_{10} is connected, and the second I/O equipment code is selected. This accomplishes the switching of the first and second I/O equipment codes.



(a) 改动前 (b) 改动后

图5 公共设备码拼合线路与设备码输入线路的改动部分

(a) before modification (b) after modification

Figure 5 Modified Portions of the Common Equipment Code Composite Circuit and Equipment Code Input Line

2. Input interface. According to the original design, a teletype is primarily intended to be connected to the second I/O port, and the input

serial data pulses are produced with key contacts, as shown in figure 6. This signal level is compatible with TTL logic levels, and can be directly sent to the input terminal of the #114 chip. However, according to the standards for the RS-232C serial interface, the ADM-5 display levels for sending data are ± 12 volts, so in order to connect this signal line with TTL circuits, before the serial data codes sent by the display enter the input interface, we should use a single tube receiver and convert the ± 12 volt transmitted levels to TTL logic levels. The single tube receiver that we use is shown in figure 7. There is no strict requirement as to the switch triodes and diodes in the receiver, as the majority of other similar function silicon tubes can all substitute. At the same time, empty substitution of #114-5,6,7 with a NOT gate is acceptable.

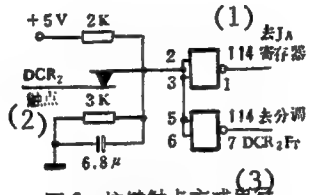


图6 按键触点方式串行脉冲的输入

(1) to J_A register (2) DCR_2 contact (3) to allocated DCR_2 F_T

Figure 6 Serial Pulse Input in Key Contact Mode

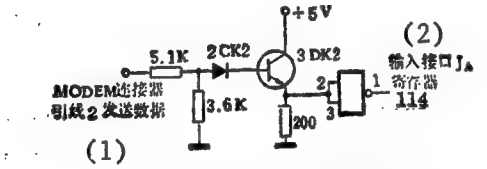


图7 RS-232C单管接收器

(1) lead 2 of the MODEM connector transmits data

(2) input interface J_A register

Figure 7 RS-232C Single Tube Receiver

3. Output Interface

a. Five to eight unit system select. The output interface provides use of a 5 or 8 unit second I/O port selection circuit, as shown in figure 8, that is, the control gate output leads J_{A8}(#77), J_{A9}(#87), and J_{A10}(#107) are short connected. Because the ADM-5 is an 8 unit character display, then short connect W_3, W_5, and W_7 to allow the host computer to provide an 8 unit ASCII code character to the display.

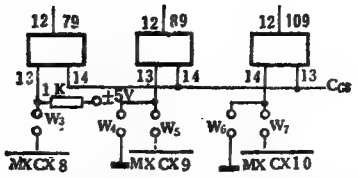


图 8　输出接口中的 5-8 单位制式选择电路

Figure 8　5-8 Unit System Select Circuit in an Output Interface

b. RS-232 drivers. In order to convert the TTL levels sent to the display by the DJS-130 computer through the second I/O port to EIA RS-232C signal levels, we have added the driver shown in figure 9 to the output interface. When the input is low, the transistor cuts off, and the output is logical 1; when the input is high, output is logic zero, which accomplishes the goal of two level conversion.

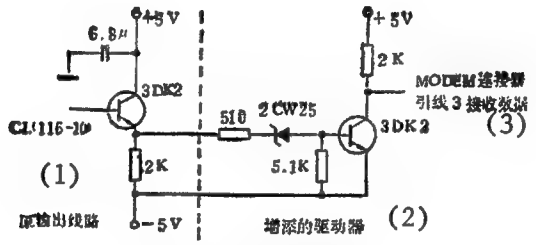


图 9　RS-232C 驱动器

(1) Original output circuit　(2) added driver　(3) MODEM connector lead receives data

Figure 9　Added driver

4. On-line methods for the ADM-5. The EIA RS-232C connector is a 25-line DB-25 type cable plug, and for easier connection each lead is standardized. Standard principles of RS-232C serial data communications require that we use three strand wire for signal transmission connections, that is, data transmission, data reception, and signal ground. Behind the ADM-5 display there is an RS-232C standard MODEM receptacle, from which receptacle leads out three twisted pairs for easy connection to computers. The three wires lead, respectively, from:

lead 2: transmit data (T_XD), representing the I/O key contact DCR_2;

lead 3: receive data (R_XD), representing the I/O DCC_2LT;

lead 7: signal ground.

At the same time, we want to connect lead 4 request-to-send (RTS) high (all that needs to be done is set the configuration switch S3-5 to "ON"), suspend lead 5 clear-to-send, that is, as high level, allowing the ADM-5 display to rest in a ready to send state.

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APPLIED SCIENCES

COMPUTER OPTIMIZATION OF PENNING POLARIZED ION SOURCE

Tianjin TIANJIN DAXUE XUEBAO [JOURNAL OF TIANJIN UNIVERSITY] in Chinese No 4, Dec 84 pp 103-119

[Article by He Naiwen [0149 0035 2429], Department of Physics]

[Text]

Abstract

A CBM 4032 computer system is described which has been set up to control the Penning Polarized Ion Source. A detailed describtion of the control program and the underlying philosophy is given. This program, besides setting and logging parameters, performs an optimization of the ion source output. A free definable figure of merit, being composed of the current of the ionizer and its variance, has proven to be an effective means in directing the source optimization.

The performance that has been reached during first successful tests is reported.

1. Introduction

Low beam intensities, the old weakness in polarized physics has been overcome through the development of high efficiency ionizers. A new technology was brought up by the construction of a superconducting strong field ionizer by the Institut für Angewandte Physik in F.R.Germany[2]. The high magnetic field of the superconducting solenoid allowes a penning discharge to take place in the ultrahigh vacuum of the ionizer. The nearly tenfold increase in efficiency marked a significant progress compared to the older generation of ion sources.

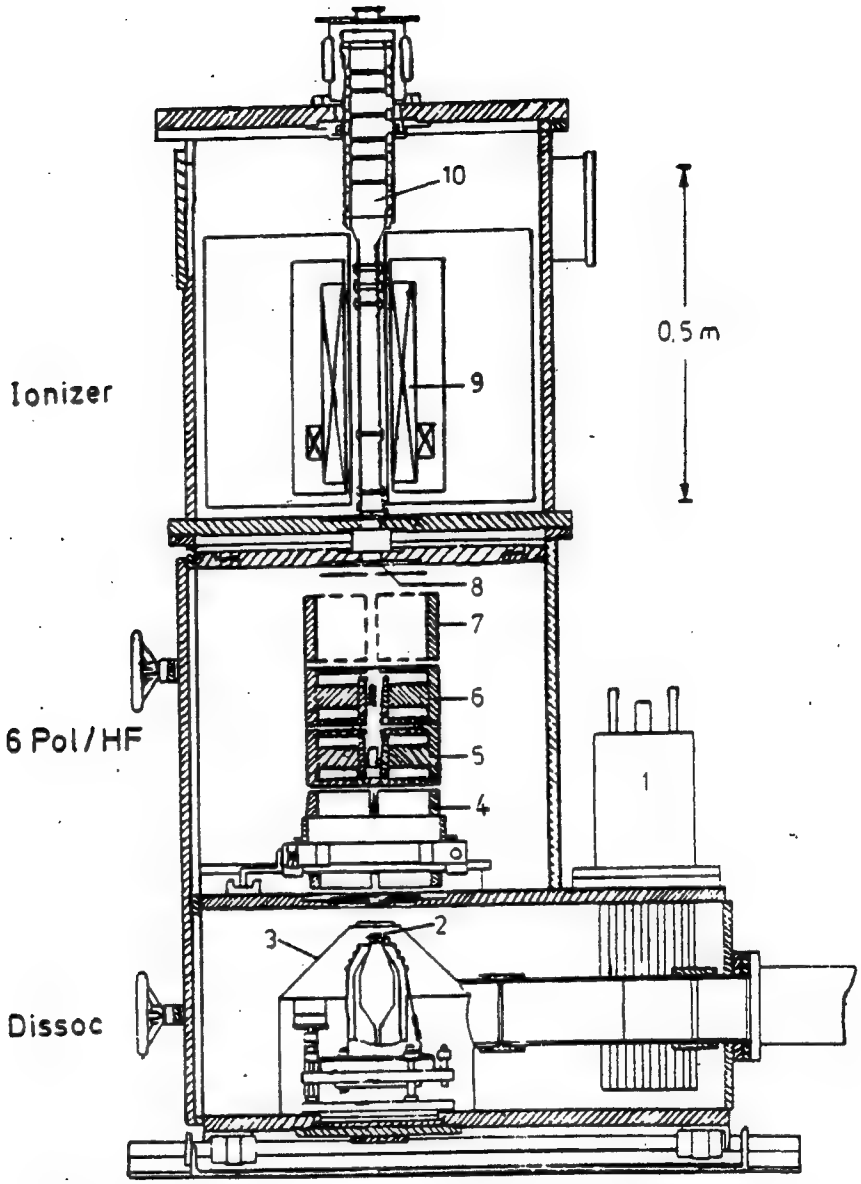


Fig. 1: Schematic of the Penning Polarized Ion Source

1 Kryogenic pump, 2 LN cooled copper nozzle,
3 Dissociator, 4 Suxtupole I,
5, 6 RF Transition units, 7 Compressor sextupole
8 Atomic deam detector, 9 Superconducting solenoid
10 Extraction System

Now it was possible to obtain beam currents comparable to those delivered by standard ion sources.

Some complication resulted from the somewhat increased number of parameters and the drifting of the optimal performance, due to varying vacuum and surface conditions, parameters that can hardly be stabilized. The first making the initial adjustment more difficult and the second giving the necessity for retuning from time to time.

The availability of low cost but powerful desktop computers stimulated the idea to set up a system that was able to control and optimize the polarized ion source. The lay out of the computer control had to include an easy manual adjustment, with the aim to substitute the old inadequate remote control system and simplify the transition from the old to the new system, especially, as at the beginning the effectiveness of the controlling program was not to foresee.

2. The polarized ion source

Fig. 1 shows the main components of the polarized source[2]. The hydrogen respectively deuterium gas is dissociated into atoms in the dissociator via a RF discharge. The cold atomic beam leaves the liquid nitrogen cooled copper nozzle and is cleaned by two skimmers. Entering the first sextupole magnet the atoms are seperated according to their electron spin state. Only the $m_j = \frac{1}{2}$ component is focused to the central axis. Two RF-transitions between the first and the second sextupole magnets allow selection of the desired nuclear spin states. The second sextupole magnet serves as a compressor sextupole[2] and gives the necessary sharp and long focal volume for the superconducting ionizer.

The Penning discharge inside the ionizer is controlled by 8 electrodes E1 through E8, the chief electrodes for the discharge mode being E1 through E6 (cf. Fig. 2). The ionizer as a whole can be set to a given beam potential thus defining the energy of the extracted ions. This allows the matching of the ions to the proper energy for injection into the cyclotron.

The schematic of the controlling high voltage power supplies is given in figure 3. The eight power supplies for the electrodes E1—E8 are mounted inside a "hot-rack". With the power supply "beam potential" a high voltage is applied to the "hot rack". Therefore, the control signals for the supplies in the "hot rack" are fed via optical links to the control unit ensuring thus the necessary isolation towards ground. The power supply connected to the einzellens matches the ion beam to the acceptance of the axial injection line.

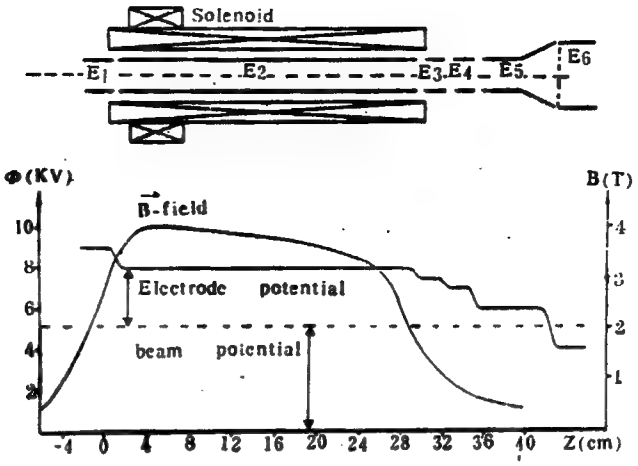


Fig. 2: Detailed view of the ionizer, with electrodes E1 through E6. Below, with the same scale a typical voltage configuration is shown together with the magnetic field B of the solenoid.

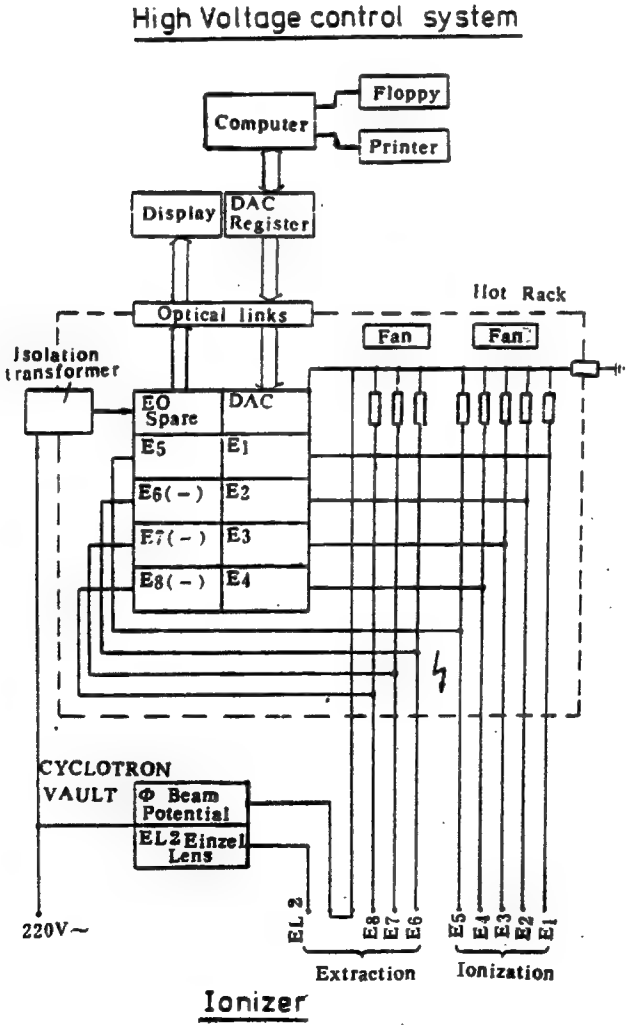


Fig. 3: High voltage power supplies E1-E8 and their connection to the electrodes and the computer

3. Computer configuration and interfacing circuits

The system that has been set up comprises a CBM-4032 desktop computer with a floppy disk as a mass storage for programs and data and a matrix printer for hard copies of data. A schematic is shown in fig. 4.

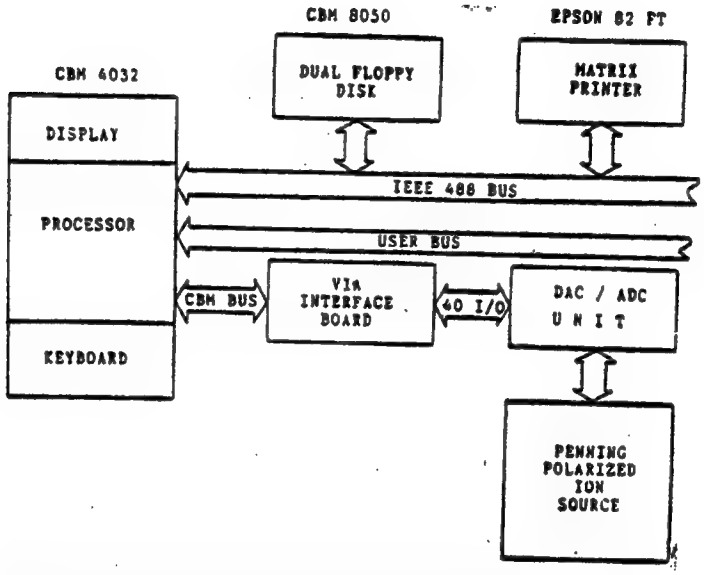


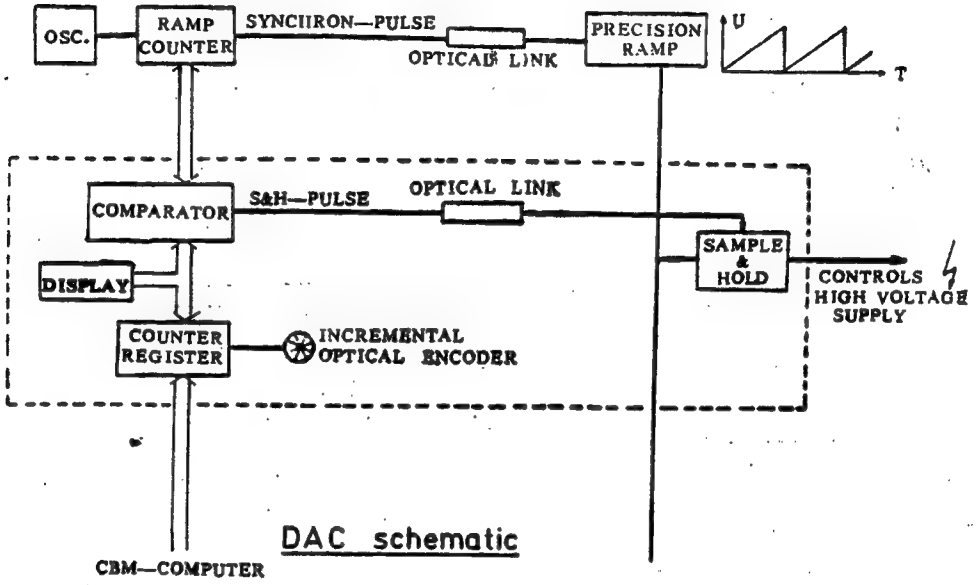
Fig. 4: Schematic of the CBM-4032 computer system.

For our purposes it was necessary to expand the number of input/output channels. Therefore, a separate PC-board with two versatile interface adapter IC's 6522 was connected to the CBM-bus giving additional 40 I/O channels for communicating with external devices.

To allow external control of the high voltage supplies the units were modified for remote control with a signal between 0 and 10 Volt. This voltage comes from the sample and hold circuit shown in Fig. 5, which outlines the digital to analog conversion scheme used in our case. The requirements were an accuracy of 10^{-4} of full scale for the adjustment and a high monotony to avoid erroneous adjustments. Furthermore, the high potential of the "hot rack" had to be bridged. Simple adjustment either manually or by the computer had to be provided.

The basic elements in Fig. 5 are the 4 digit BCD ramp counter driven by a 500 KHz oscillator. With each synchronizing pulse the precision ramp going up to 10 volts is reset to zero. The control of the high voltage output occurs

with the 4 digit BCD counter/register which can be set by the computer or changed with the incremental optical encoder manually. If the digital comparator detects equality it sends a sample pulse to the sample and hold unit and thus locks the corresponding voltage of the precision ramp. The details of the circuits are shown in ref. 1.



DAC schematic

Fig. 5

4. Parameter space

The present system has control over eight parameters, the eletcrodes E1-E8. Those are connected to high voltage power supplies variable between 0 and 10 KV. But not all values adjustable are reasonable, some are even dangerous and may lead to destruction. Therefore, it is neeessary to limit the variable settings to a restricted parameter space. Upper and lower limits as well as limits between parameters can be set and altered according to the needs. Before the computer makes an adjustment it checks according to this list if the new value is within the allowed range.

A memory section of 4 K contains those parameter limitations. It can be stored and loaded separately, thus saving typing effort. Provisions are made to expand the number of parameters, foremost, to the elements of the axial injection line. The structure of the program is built to permit an easy expansion.

5. System software

5.1 The problem situation

A device like the ionizer obeys complicated internal processes controlled by the high voltages of the electrodes E1-E8. The large number of parameters lengthen the tuning procedure, especially, since the signal which is being optimized, the ion current, can undergo strong fluctuations due to different discharge modes inside the ionizer. Besides this difficulty, another problem is thermal drift and drift due to aging. The latter may be of great importance since the surface conditions are crucial for the discharge as well as the vacuum inside the ionizer. Both parameters can hardly be stabilized. The only way to counter those changes is to vary the voltages of the electrodes in order to hold the optimum current. This results in the need of retuning the source from time to time by an operator. From this, three basic tasks can be derived. First, initializing the source and bringing it up with a standard parameter set. Second, searching the parameter space for an optimum value of the beam current. Third, go in a hold mode and keep the source on the optimum.

The difficulty in laying out the program structure results from transforming the knowledge of an experienced operator into a workable program code.

A theoretical approach would be to describe the output current IC as a function of the parameters E1-E8

$$IC = f(E_1, E_2 \cdots E_8, t)$$

Unfortunately it contains a dependance of the time t as mentioned before. Besides this, the hypersurface spanned by E1-E8 is not known analytically. Certainly, it is of a very complicated nature containing many discontinuties due to the different discharge modes. From the previous experience it is clear that the maximum ion current alone may not be the best signal. Therefore, we have created a figure of merit (FGM) which took into account the stability of the discharge mode. The measurement of the current had to be done in a repetitions way to reduce the influence of accidental fluctuations. By having for instance five current values available for a specific parameter set it is possible to compute a mean and a standard deviation which allows a judgement on the stability of the discharge mode.

We used for our purposes a figure of merit defined as $FGM = (IC)^A / (\sigma^2)^B$. IC is the measured ion current and σ^2 is its variance. The exponents A and B can be chosen for best results in current respectively stability, according to the needs of the experiment. The sensitivity to strong fluctuations also

allows to avoid being trapped by instable modes.

5.2 Tracing the optimum

There are two basic methods for finding the maximum of a given function[3]

i) The grid search where each parameter is optimized separately. Assuming the maximum can be described by a parabola, a parabolic extrapolation is used. Successive iteration for each parameter yields the desired maximum.

ii) In the gradient search the maximum is reached in a more direct way by calculating the approximate vector towards the maximum. All parameters are adjusted simultaneously in a way that leads to the most rapid growth of the value to be optimized.

Fig. 6 shows the paths for a grid search and a gradient search in a contour plot of the ion current with arbitrary parameters a_1 and a_2. Comparing the two methods one can say in general that the first one is simple in its application, although may take longer to find the maxtmum. The second is much faster in its movement towards the maximum, but takes a much greate computational effort. In our case the choice was a modified grid search since the necessary computation for the gradient search was too long and unreliable due to the fluctuations in current. In the modified grid search the parameter is varied until the maximum is exceeded. With the last three points, a parabola is calculated and the parameter is set to the optimum. Then the next parameter is optimized and so on until it starts over with the first parameter.

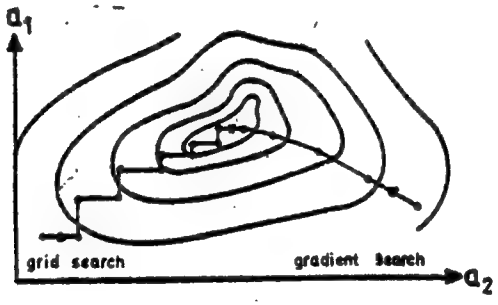


Fig. 6: Comparing grid search and and gradient search

5.3 Pseudoparameters

A problem may arise in such a simple grid search, when there is a strong coupling between the different parameters, i.e. the best value for one parameter depends heavely on the others. In this case the creation of pseudoparameters can be fo great help. A pseudoparameter is created for instance by a linear

combination of several parameters. If one changes the voltages of all the electrodes by the same amount one has the same effect as if one would change the beam potential thus allowing to match in a direct way the injection energy.

5.4 Software architecture

The software is composed of two programming languages. For ease of application "Basic" is used in the main body of the program and to perform fast tasks and communication with the interfaces assembler language is taken. Strong structuring and the use of program modules in a tree like architecture ensures the transparency needed for clarity and ease of further expansion.

This is supported, too, by detailed flow charts of the programs documented in the appendix. Spectial memory sectors which can not be readily reached by the Basic program are used for variable sets which determine the behaviour of the controlling software.

Extensive use is made of the many routines available in the system ROM of the CBM 4032 computer resulting in a very dense program code. Multi tasking is provided and can be used for instance to control the ion source in the hold mode, when not much CPU time is necessary.

Attention has been given to make the program self documenting and to give clues to the user which steps to take. A consistent layout of the screen eases the dialog between man and machine. Many comment lines in the program facilitate the understanding and help in the case of desired alterations.

6. Ion source simulation with a second computer

As the operation of the ion source needs large preparation and is restricted by the scheduled time with the cyclotron, it was advantageous to simulate approximtely the behaviour of the polarized ion source with a second CBM 4032 computer. Thus it was possible to control and correct the software in a convenient way.

The two computers were connected via their user ports. The actual parameter set was transferred to the second computer, which used those values to compute an ion current. A program was made to simulate an optimum, random fluctuations, and hysteresis. The handler routine of the controlling computer for reading the ion current was modified to read a current value calculated by the second computer.

Table 1 shows the result of such a simulation for parameter 1 and 2. The random current fluctuation was set to 10%. The figure of merit was taken

with $(IC)^2/(\sigma^2)^0$, thus only the ion current IC was weighed. Six measurement cycles were used. As can be seen the computer reaches the optimum which was set to 300 for both parameters with high precission.

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ADR.: 1 WERT: 400 DAC-GELESEN 0 ADR.: 9 WERT: 46028 STROM GELESEN
ADR.: 1 WERT: 272 DAC-GESCHR. 0 ADR.: 9 WERT: 46407 STROM GELESEN
ADR.: 1 WERT: 400 DAC-GESCHR. 0 ADR.: 9 WERT: 46054 STROM GELESEN
ADR.: 1 WERT: 272 DAC-GESCHR. 0 ADR.: 9 WERT: 46392 STROM GELESEN
ADR.: 1 WERT: 400 DAC-GESCHR. 0 ADR.: 9 WERT: 46049 STROM GELESEN
ADR.: 1 WERT: 272 DAC-GESCHR. 0 ADR.: 9 WERT: 46414 STROM GELESEN
ADR.: 1 WERT: 400 DAC-GESCHR. 0 ADR.: 9 WERT: 46033 STROM GELESEN
ADR.: 1 WERT: 272 DAC-GESCHR. 0 ADR.: 9 WERT: 46426 STROM GELESEN
ADR.: 1 WERT: 400 DAC-GESCHR. 0 ADR.: 9 WERT: 46028 STROM GELESEN
ADR.: 1 WERT: 272 DAC-GESCHR. 0 ADR.: 9 WERT: 46405 STROM GELESEN
ADR.: 1 WERT: 400 DAC-GESCHR. 0 ADR.: 9 WERT: 46045 STROM GELESEN
ADR.: 1 WERT: 272 DAC-GESCHR. 0 ADR.: 9 WERT: 46402 STROM GELESEN

ADR.: 1 WERT: 272 DAC-GELESEN 0 ADR.: 9 WERT: 46399 STROM GELESEN
ADR.: 1 WERT: 144 DAC-GESCHR. 0 ADR.: 9 WERT: 45517 STROM GELESEN
ADR.: 1 WERT: 272 DAC-GESCHR. 0 ADR.: 9 WERT: 46403 STROM GELESEN
ADR.: 1 WERT: 144 DAC-GESCHR. 0 ADR.: 9 WERT: 45519 STROM GELESEN
ADR.: 1 WERT: 272 DAC-GESCHR. 0 ADR.: 9 WERT: 46385 STROM GELESEN
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ADR.: 1 WERT: 298 DAC-GESCHR. 0
ADR.: 2 WERT: 200 DAC-GELESEN 0 ADR.: 9 WERT: 46451 STROM GELESEN
ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46799 STROM GELESEN
ADR.: 2 WERT: 200 DAC-GESCHR. 0 ADR.: 9 WERT: 46417 STROM GELESEN
ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46806 STROM GELESEN
ADR.: 2 WERT: 200 DAC-GESCHR. 0 ADR.: 9 WERT: 46415 STROM GELESEN
ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46783 STROM GELESEN
ADR.: 2 WERT: 200 DAC-GESCHR. 0 ADR.: 9 WERT: 46428 STROM GELESEN
ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46797 STROM GELESEN
ADR.: 2 WERT: 200 DAC-GESCHR. 0 ADR.: 9 WERT: 46420 STROM GELESEN
ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46797 STROM GELESEN
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ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46810 STROM GELESEN

ADR.: 2 WERT: 328 DAC-GELESEN 0 ADR.: 9 WERT: 46811 STROM GELESEN
ADR.: 2 WERT: 456 DAC-GESCHR. 0 ADR.: 9 WERT: 45902 STROM GELESEN
ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46783 STROM GELESEN
ADR.: 2 WERT: 456 DAC-GESCHR. 0 ADR.: 9 WERT: 45902 STROM GELESEN
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ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46777 STROM GELESEN
ADR.: 2 WERT: 456 DAC-GESCHR. 0 ADR.: 9 WERT: 45940 STROM GELESEN
ADR.: 2 WERT: 328 DAC-GESCHR. 0 ADR.: 9 WERT: 46799 STROM GELESEN
ADR.: 2 WERT: 456 DAC-GESCHR. 0 ADR.: 9 WERT: 45898 STROM GELESEN
ADR.: 2 WERT: 302 DAC-GESCHR. 0
```

Table 1: Output of a computer simulation.
ADR 1 is parameter 1, ADR 2 parameter 2.
The computed values are 298 and 302, marked with an arrow.

7. Practical tests of the optimizing software

As stated before no exact knowledge of the dependence on the figure of merit (FGM) of the eight parameter exists. Therefore, it was important to experience whether in this digital closed loop control system the stability criteria would be fulfilled. Fig. 7 shows copies of a chart recorder plot with the total ion current (Y-axis) versus time (X-axis).

The charts show the ionizer under computer control on the left side. Only the ion current was taken as FGM. No oscillation or runaway situation is seen in the plot which demonstrates the stability of the control. Beginning at the time marked with an arrow it was tried manually by different operators of the source to improve the current. As can be seen the manual attempt lead to a poorer performance in both cases.

Fig. 8 shows a study with different definitions of the FGM. One sees clearly how the output of the source is affected by the various definitions of the FGM. On the far left only the current signal I is optimized. As soon as the figure of merit (FGM) is changed to $I^4/(\sigma^2)^{\cdot 5}$ the settings of the ionizer are altered by the computer to give a lower but more steady current. Weighing the current stronger ($FGM = I^8/(\sigma^2)^{\cdot 25}$) leads to an improvement in current until with the definition $I^8/(\sigma^2)^{\cdot 125}$ nearly the old current value is reached.

Another example that demonstrates the behaviour of the control loop is show in Fig. 9. The ion source, after having been optimized by hand, is deliberatly detuned and control is rendered to the computer. The numbers on the X-axis show the iteration cycles. Already after one iteration cycle of all

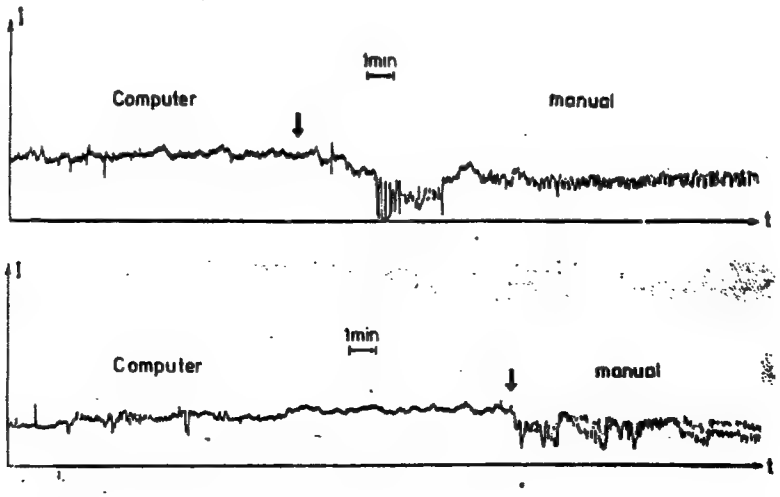


Fig. 7: Ion current with different tuning procedures.

parameters a current value is obtained that exceeds the old maximum. The next cycle gives an additional improvement of the current and reaches nearly the steady state.

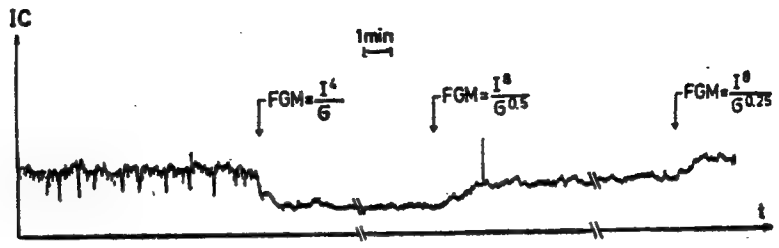


Fig. 8: Ion current under different Figure of Merit

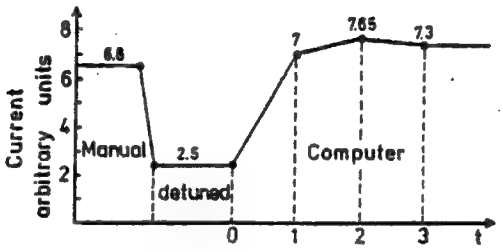


Fig. 9: Ion current versus iteration cycle

The time characteristic is given mostly by the measuring time. To ensure enough accuracy the current is measured for 60 ms. For two values of a parameter and 5 measurements each this adds up to 600 ms. Furthermore, a 60 ms delay is needed for the high voltage power supply to settle to a new value, thus 600 ms have to be added to a total of approximately 1.3 s. Assuming that it takes in the average adout 5 steps to determine a maximum it takes 6.5 sec per parameter or a total time of 52 sec for one full 8 parameter cycle. This characteristic time constant is roughly seen in Fig. 8 after each change of the FGM. This time will be of course much less if fewer steps are needed to reach the maximum. Further improvement in speed, if necessary, could be obtained through the use of shorter current measurements and faster responding high voltage power supplies.

8. Conclusion

This work has shown that by means of a low cost desktop computer system it is possible to optimize even such a complex apparatus like a polarized ion source. The difficulties result not that much from the hardware and the inter-

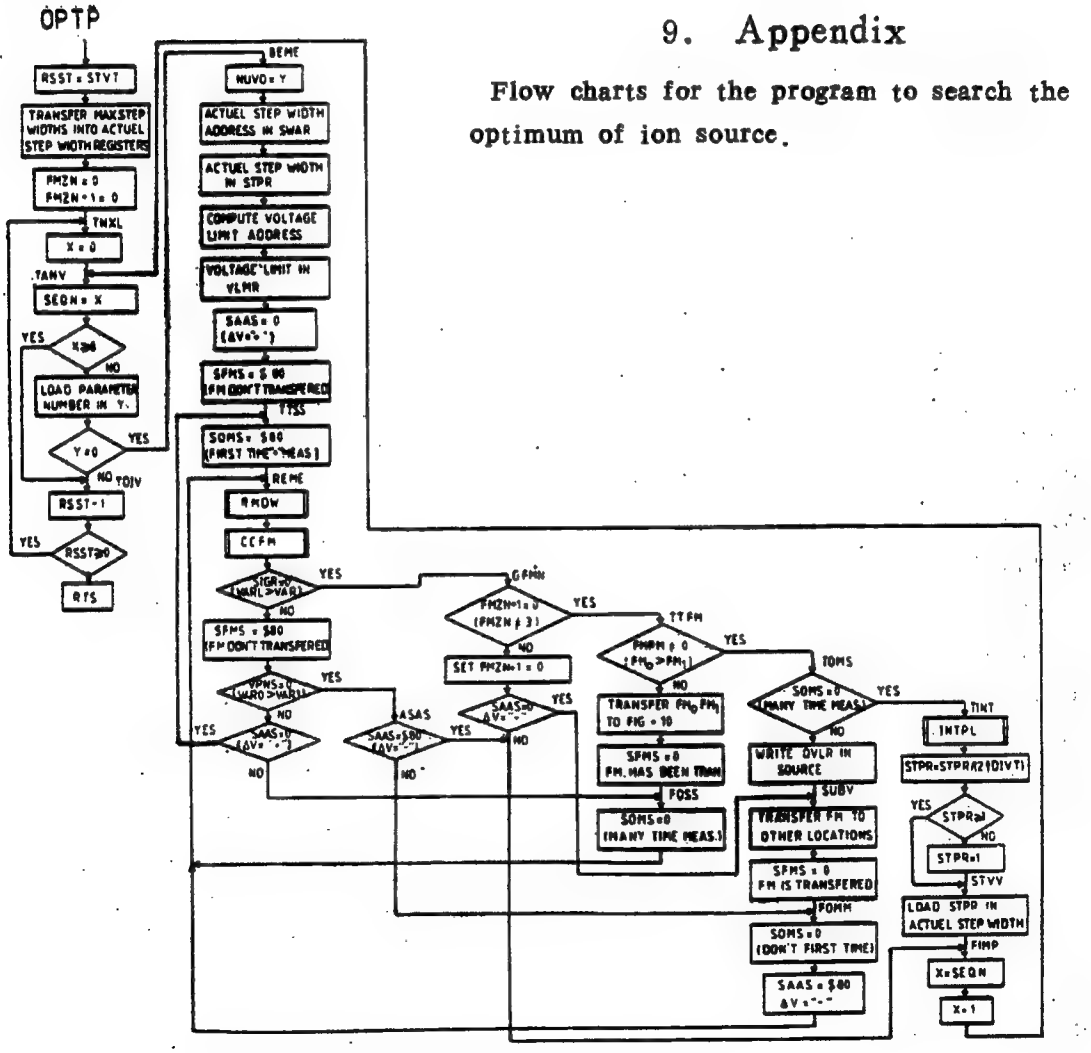
faces but from the establishment of a reliable program code which incorporates the operation experience thus far obtained in manual tuning.

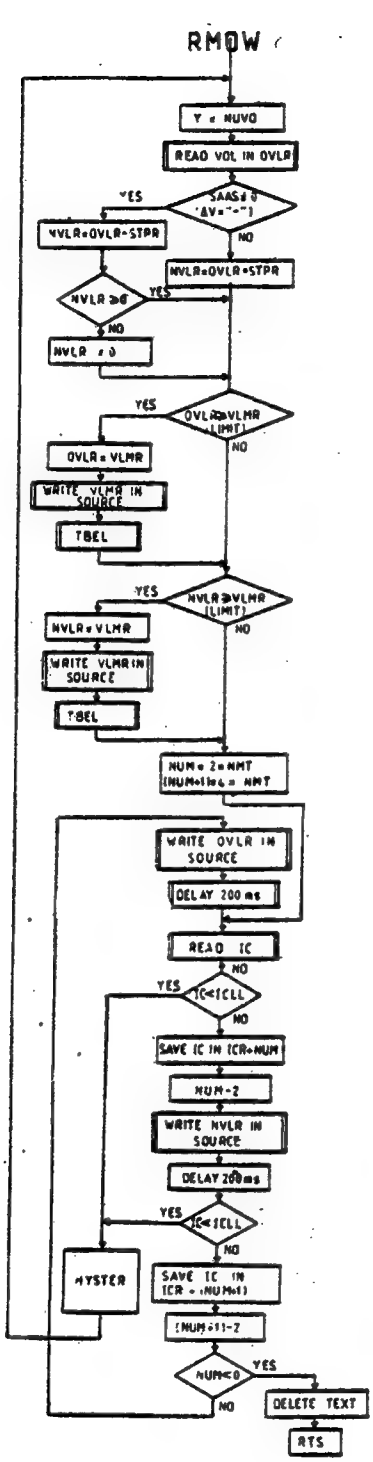
The algorithm used has proven to be a potent means for finding an optimum under various conditions of the ion source. A strongly structured program architecture was applied to allow easy expansion and alteration in hard and software. The successful test showed clearly the superiority of the computer tuning versus manual tuning procedures.

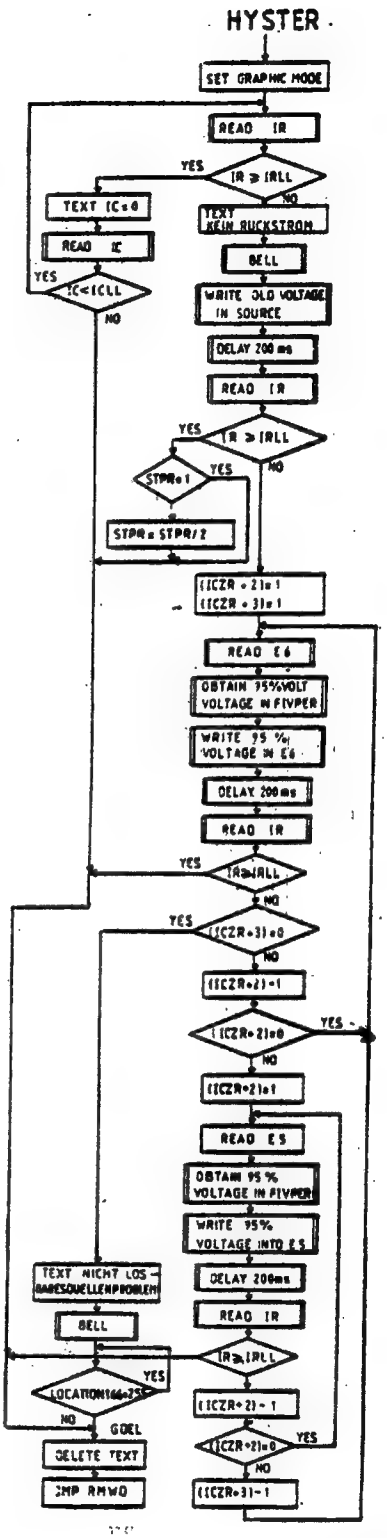
The system is configurated in a way that allows its application for optimizing other processes too. For instance in the case of the Isochronous Cyclotron, the inclusion of the axial injection line in the control system would be of great value.

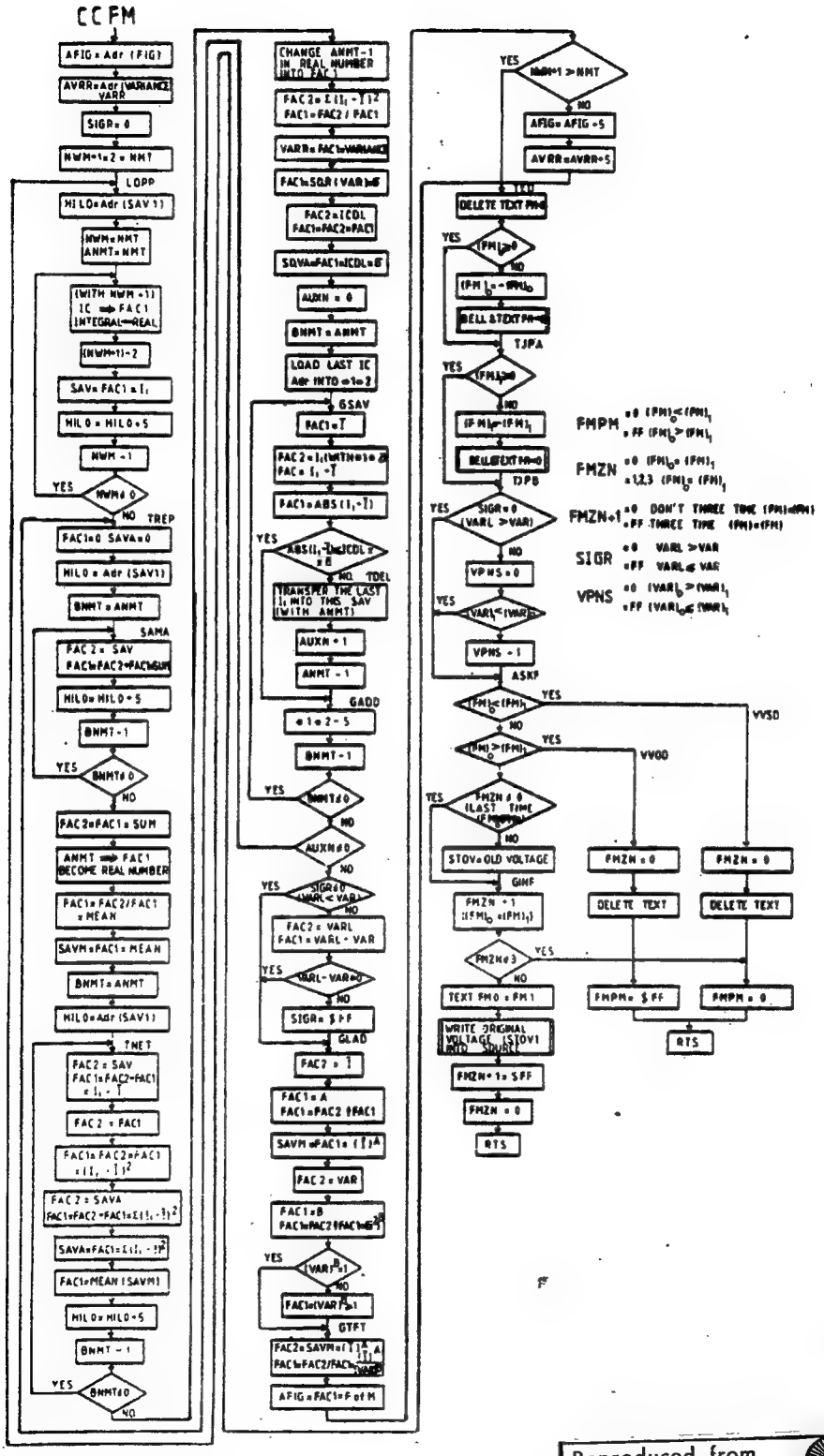
9. Appendix

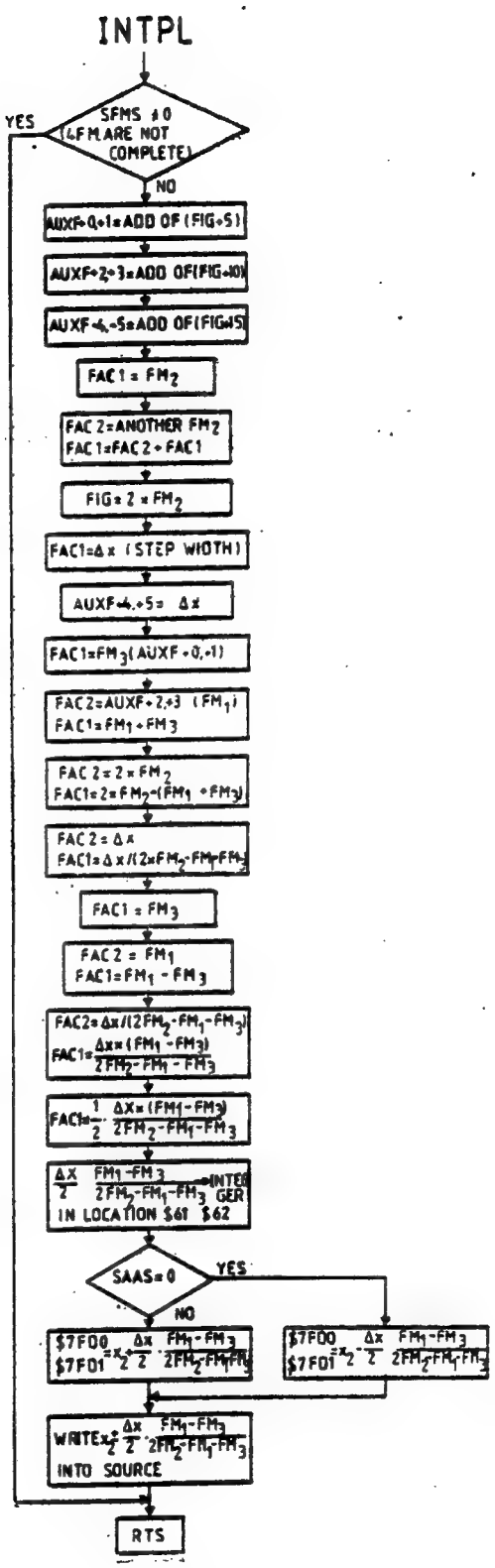
Flow charts for the program to search the optimum of ion source.










INTPL
SFMS ≠ 0 (FMARE NOT COMPLETE)
YES
NO
AUXF+0,+1=ADD OF (FIG+5)
AUXF+2,+3=ADD OF(FIG+10)
AUXF+4,+5=ADD OF(FIG+15)
FAC1 = FM2
FAC 2=ANOTHER FM2
FAC1=FAC2 + FAC1
FIG= 2 x FM2
FAC1=Δx (STEP WIDTH)
AUXF+4,+5= Δx
FAC1=FM3(AUXF+0,+1)
FAC2=AUXF+2,+3 (FM1)
FAC1=FM1+FM3
FAC 2= 2 x FM2
FAC1= 2=FM2-(FM1 +FM3)
FAC 2 = Δx
FAC1=Δx/(2xFM2-FM1-FM3)
FAC1 = FM3
FAC 2 = FM1
FAC1=FM1 - FM3
FAC2=Δx/(2FM2-FM1-FM3)
FAC1=Δx x (FM1 - FM3) / 2FM2-FM1-FM3
FAC1=1/2 Δx x (FM1-FM3) / 2FM2-FM1-FM3
Δx/2 FM1-FM3 / 2FM2-FM1-FM3 →INTEGER IN LOCATION $61 $62
SAAS=0
YES
NO
$7F00 Δx/2 FM1-FM3 / 2FM2-FM1-FM3
$7F01 =x2
$7F00 Δx/2 FM1-FM3 / 2FM2-FM1-FM3
$7F01 =x2
WRITE x2 Δx/2 FM1-FM3 / 2FM2-FM1-FM3 INTO SOURCE
RTS

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(Paper received on 30 December 1983)

CSO: 4010/1012

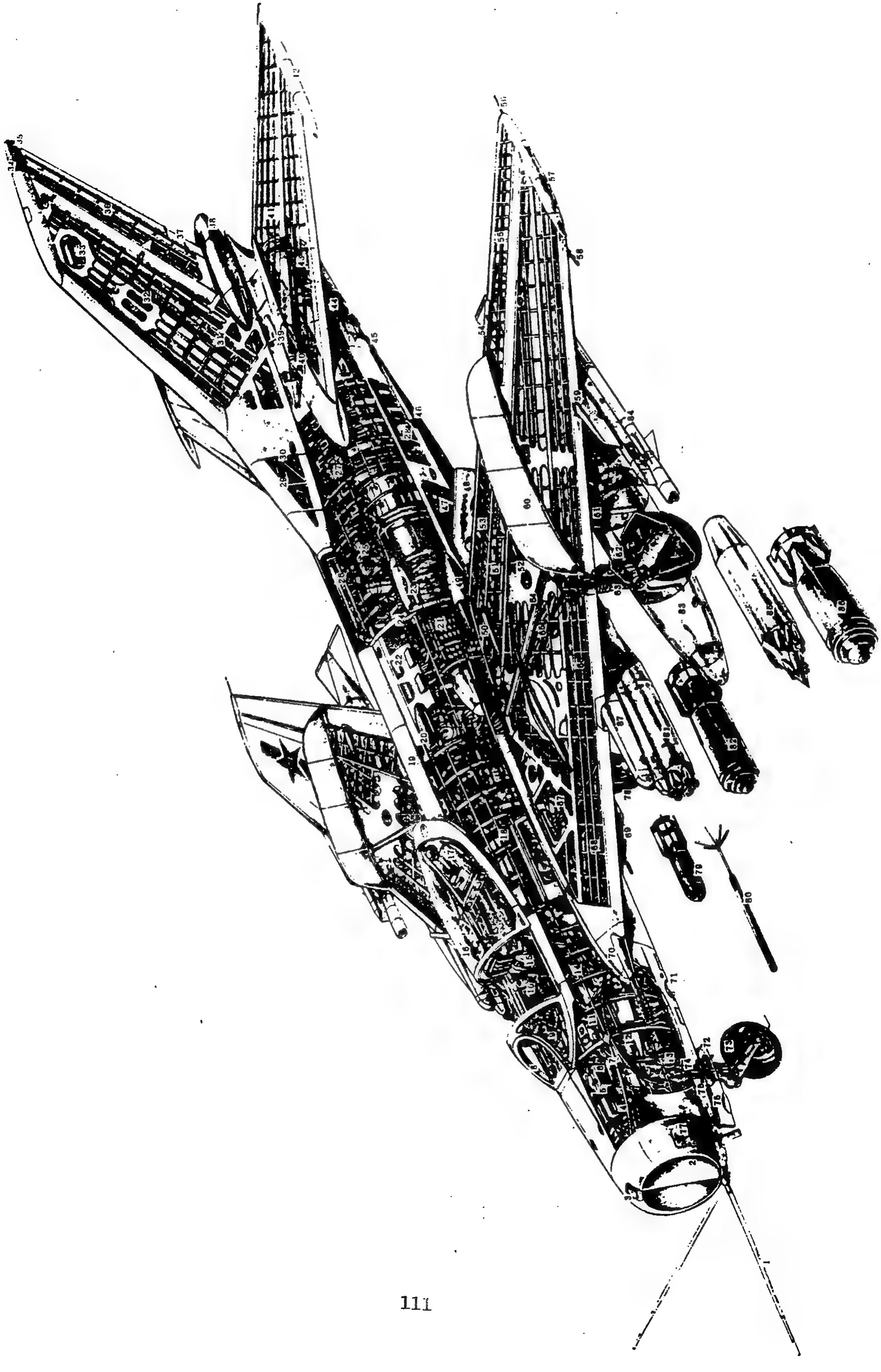
APPLIED SCIENCES

CUTAWAY VIEW OF CHINESE-MADE SUPERSONIC FIGHTER PUBLISHED

Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE] in Chinese No 8, Aug 85, insert

[Text] [Illustration]

[See illustration on following page]



Key to illustration on preceding page:

1. Pilot tube
2. Air intake
3. Gun camera
4. UHF receiver
5. Storage battery
6. Radio altimeter transmitter/receiver
7. Ram intake
8. Cockpit forward windscreen
9. Gunsight
10. Starboard control console
11. Control stick
12. Control pedals
13. Oxygen bottle
14. Starboard control console throttle
15. Ejection seat
16. Rearward-sliding canopy
17. Cockpit pressure system
18. No. 1 and No. 2 fuel tanks
19. Dorsal fin
20. Ram air intake
21. Turbojet engine
22. Open cooling vent
23. Air intake
24. Connection for fore and aft fuselage sections
25. Fuel tank
26. Rudder control linkage
27. Refueling port for No. 3 and No. 4 fuel tanks
28. No. 4 fuel tank
29. Horizontal stabilizer booster
30. Tailfin forward spar
31. Tailfin rear spar
32. Radio compass
33. Tail warning unit
34. Warning antenna fairing
35. Tail light (white)
36. Rudder
37. Rudder trim tab
38. Drogue chute housing
39. Horizontal stabilizer booster fairing
40. Tail plane pivot
41. Movable tail plane
42. Anti-vibration trim
43. Hydraulic-operated jet nozzle
44. Cool air intakes
45. Tail guard assembly
46. Ventral fin
47. Speed brake housing
48. Speed brake
49. Wingroot fairing
50. Wing flap hinge fairing
51. Aft wing spar
52. Aileron control assembly
53. Flap
54. Aileron trim tab
55. Aileron
56. Static electricity brushes
57. Wingtip navigation light (red on port, green on starboard)
58. Radio altimeter antenna
59. Wingtip ordnance attachment point
60. Wing fence
61. Attachment point
62. Main gear cover
63. Main gear
64. Main wing spar
65. Main gear housing
66. Cannon ammunition magazine and belt
67. 30mm cannon
68. Compressed air bottles
69. Ventral fuselage speed brake
70. Cannon fairing
71. Landing light
72. Nose wheel landing gear cover
73. Nose wheel gear
74. Nose gear housing
75. Taxiing light
76. Rangefinder antenna
77. Inspection hatch
78. Main gear door
79. Bomb
80. Rocket
81. Rocket launcher
82. Bomb
83. Auxiliary fuel tank [drop tank]
84. Air-to-air missile [AAM]
85. Rocket launcher
86. Bomb
87. Ordnance attachment point

CSO: 4008/411

APPLIED SCIENCES

CAD PROGRAM FOR HIGH-POWER ELECTRON GUN WITH ANNULAR CATHODE DESCRIBED

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese No 4, Nov 1984 pp 95-97

[Article by Tu Yushan [1458 5124 0810], Institute of Electronics, Academia Sinica: "Design and Application of a High-power Electron Gun with Annular Cathode"]

[Text] This paper describes the characteristics of an electron gun with annular cathode. In order to compare design optimizations for different applications, a program for computer-aided design (CAD) has been compiled and typical examples given.

The high-power electron gun with annular cathode can achieve higher compression with a large power density, its beam is adjustable, its static electricity focusing structure is simple, it can avoid mutual contamination of cathodes and bombarded surfaces, etc. Therefore, widespared application is possible in x-ray photoetching, electron-beam smelting and evaporation installation.

The annular cathode electron gun (Figure 1), used as the electron source in an x-ray photoetching installation, is a key technology in the manufacture of sub-micro large-scale integrated circuits.[1] This type of fixed-target annular cathode electron gun has a number of advantages: (1) The x-rays' parallel degree is good over the entire photoetching surface and luminous flux is well distributed; (2) there are no mechanical revolving parts, so the equipment is highly stable and reliable; (3) it is possible to avoid the buildup on the target surface and resultant contamination, so that electron emission is maintained over a pure frequency spectrum, and, moreover, it is possible to avoid direct ion bombardment of the cathode, thereby prolonging the cathode's lifetime; (4) it is possible to use a cathode which has been impregnated with barium tungsten, a type of cathode which will not easily become deformed. Also, it has a strong toxin-resistance capability and is reliable.

The distributions of electric potential, current emission and electron orbits are not things which can be pursued directly by theoretical analytical methods. In order to carry out more conveniently the design optimization and equipment comparison for the requirements for different applications, we have compiled a complete CAD program which can calculate the dimensions of electrodes of arbitary forms (including electrodes of either arc or straight-line

formation and can also calculate the electron optical characteristics of an electrode voltage annular cathode electron gun (including current emission, cathode current density distribution, electron orbit, the distribution of density of current bombarding the target surface, etc.). The results derived from calculations using this program are basically consistent with those which have been reported in the literature.[2]

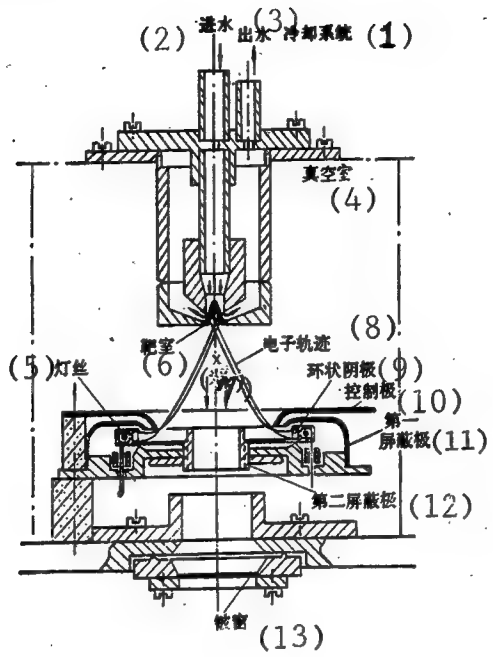


Figure 1. Structural Design of the Annular Cathode Electron Gun

Key:

(1) Cooling system
(2) Water input
(3) Water output
(4) Vacuum chamber
(5) Filament
(6) Target chamber
(7) X-rays
(8) Electron orbit
(9) Annular cathode
(10) Control gun
(11) First shielded electrode
(12) Second shielded electrode
(13) Beryllium window

In the Chinese-produced DJS-6 digital computer, we used this program to carry out calculations on about 4,500 potentials and 20 orbits. In 40 minutes we were able to obtain a set of calculation results. The specific calculation methods used in the program are omitted here, and only those pertaining to the concerned space charge are related briefly as follows: due to the considerable meandering by the orbit of electrons emitted by the annular cathode, electrons were at the outset moving in the opposite direction, so it seemed more logical to use a grid method to distribute these. Figure 2 is a schematic drawing of the grid method of distribution.

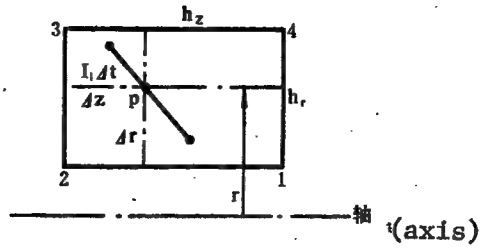


Figure 2. Schematic Drawing of Grid Method of Space Charge Distribution

The weakness of this kind of method is that the calculations done near to the axis are fairly imprecise; fortunately in this type of electron gun when electrons are near to the axis they have already attained a high speed, so the space charge has less influence. For this kind of method, the electric charge distribution formulae for orbit of electrons near to the four grid points are:

$$\Delta p_1 = I_i \Delta t \cdot a \cdot b$$
$$\Delta p_2 = I_i \Delta t \cdot c \cdot b$$
$$\Delta p_3 = I_i \Delta t \cdot a \cdot d$$
$$\Delta p_4 = I_i \Delta t \cdot c \cdot d$$

In these, Δp_{1-4} is each electron orbit's distribution step in Figure 2, and each point 1-4 is the space charge; Δt is when each electron orbit goes a step; I_i is the current carried in the i orbit; $a = \Delta z/h_z$, $b = (1-\Delta r/h_r)(1-\Delta r/2r)$, $c = 1-(\Delta z/h_z)$, $d = \Delta r/h_r [1-(\Delta r/2r)+(h_r/2r)]$.

From this, the space charge density at each point can be found.

$$\rho = \sum_i \sum_n \Delta P/\Delta V,$$

In this formula, $\sum_i$ is the sum of the orbit as it passes through a point; $\sum_n$ is the sum of the i orbit's remaining number of steps at that point.

Figure 3 is a typical design result of a high-power annular cathode electron gun x-ray source. After considerable calculation and analysis, it was confirmed that this kind of electron gun features an adjustable current (i.e., adjustable power control). After deciding on the form of the electron gun, controlling the flow along with controlling voltage will double the changes, while there will be little change in the form of the orbit.

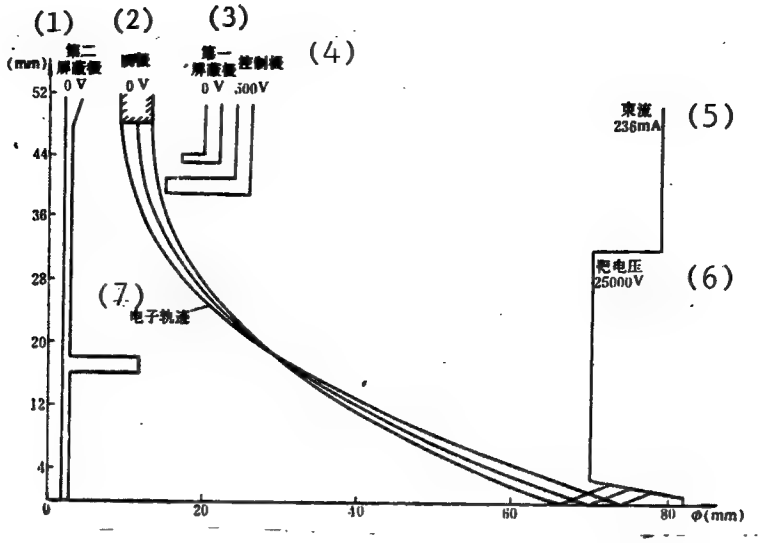


Figure 3. Electrode Structure Design and Electron Orbit Series for a Typical High-Power Annular Cathode Electron Gun X-ray Source.

Key:

(1) Second shielded electrode
(2) Cathode
(3) First shielded electrode
(4) Control electrode
(5) Beam current
(6) Target voltage
(7) Electron orbit

In view of the annular cathode electron gun's advantages related above, we expanded its use in electronic evaporation and smelting installations. Figure 4 is a typical application example. Smelted materials are put at the center, and evaporated or smelted deposits on the target surface. Due to selection of an annular cathode, the work to be smelted (or evaporated) receives equal electron bombardment (heating); therefore, the material input system requires only axial input and no rotating parts. Because of the annular cathode electron gun's high compression ratio (approximately 200), it needs only a low cathode current density, making it easy to carry out adjustment and control at different powers and power densities.

This program is convenient for carrying out CAD operations: one can choose various different dimensions and can also choose the design beam, power density and the shape of the orbit. Through calculation and comparative analysis, we discovered that a shielded electrode positioned near to the cathode was especially sensitive to the current's influence. The control electrode's position, besides influencing the beam, also has a great influence on the orbiting target position. It should be noted in particular that the position and length of the second shielded electrode near to the axis (for electric potential on the cathode, etc., see Figure 1) has a very great influence on the orbiting target and less influence on the beam. Therefore, if after adjustment of the other electron gun to the desired beam the orbiting target position is still not right, then the target can be corrected through adjustment of the orbiting target position.

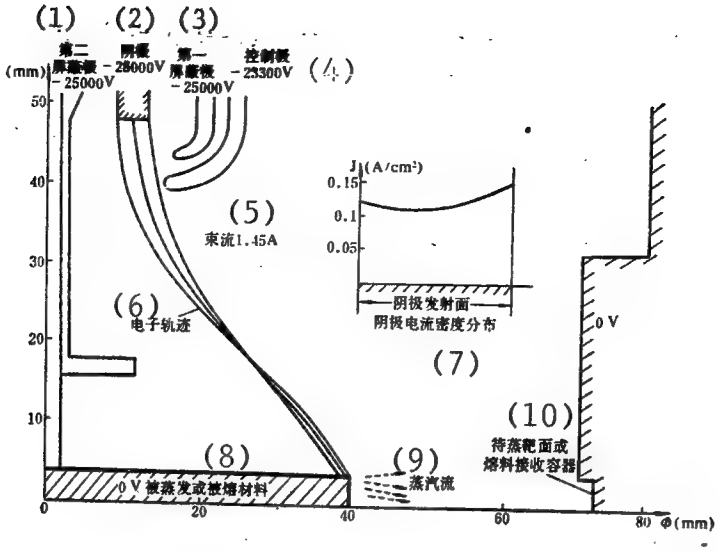


Figure 4. Annular Cathode Electron Gun for Use in Smelting and Evaporation, with Its Electron Orbit.

Key:

(1) Second shielded electrode
(2) Cathode
(3) First shielded electrode
(4) Control electrode
(5) Beam current
(6) Electron orbit

FOOTNOTES

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12625
CSO: 4008/242

LIFE SCIENCES

PROPOSALS FOR BIOENGINEERING DEVELOPMENT DISCUSSED

Beijing GUANGMING RIBAO in Chinese 14 Jun 85 p 3

[Article by Ju Naihu [1446 0035 3822]: "Some Proposals for Bioengineering Development"]

[Text] Bioengineering is both a new synthetic technology and an intellectually concentrated new industry. It requires a large contingent of specialized personnel well versed in advanced science and technology, as well as precision instruments and equipment. In order to accelerate China's bioengineering development we must give full play to our advantages--the Academy of Sciences, a wide range of disciplines in institutions of higher learning, abundant scientific and technological resources and convenient cooperation to tackle key problems--to form a Chinese institute of bioengineering as quickly as possible. Those large and medium cities that possess the conditions to do so may as appropriate establish the relevant research organizations, though they must pay attention to rational distribution and guaranteed priorities and not rush headlong into action.

Bioengineering is a burgeoning discipline with extremely broad applications. We must encourage scientists and technologists to have the drive to blaze new trails, and we should not artificially limit the scope of their research or hamper their initiative. In the author's opinion, it is inadvisable to confine the scope of bioengineering research to the four areas of genetic engineering, enzyme engineering, cytoengineering and fermentation engineering alone. That way we would exclude from the scope of bioengineering certain fields, such as bioelectronics, that are internationally being actively explored, making rapid progress and have promising futures.

In order to develop bioengineering we must select the proper breakthroughs, emphasize development and spur the rest onward. Abroad, medical engineering is always the branch of bioengineering that receives the most attention, with the fermentation industry also occupying a fairly important position. China's fermentation industry is rather backward, with the result that large quantities of farm and sideline products fail to be promptly and effectively processed for multipurpose use and huge losses are incurred. I feel that we must now make every effort to develop the fermentation industry and fully exploit and utilize microbial resources. We must adopt advanced fermentation techniques and achieve multilevel intensive processing of all kinds of products and waste

products, inclusive of the agricultural, forestry, animal husbandry, sideline and fishery industries. Thus we can make the best use of things and turn wastes into treasures. China is a huge nation of one billion people, and agriculture is the basis of the national economy. Consequently we must enhance our research into the applications of bioengineering in agriculture. This includes the development of recombinant DNA techniques and cytomixis techniques to improve animal and plant varieties and establish an agricultural, forestry and aquatic product gene pool. This approach will not only bring about a major transformation in China's agriculture, it will also give great impetus to development in the entire national economy.

In addition, we must also strengthen our research work on the weak leaks within the field of bioengineering. As far as the situation in other countries is concerned, right now the field in which investment is greatest and research progress is fastest is the area of genetic engineering. However, the majority of research achievements are still in the laboratory phase. If we really want to provide large quantities of products for society we must adopt biochemical engineering techniques. Comparatively speaking, biochemical engineering is a rather weak link, particularly in our domestic situation. Now biochemical engineering research is beginning to receive attention on the international scene: various types of computer-controlled fermentation tanks have been brought out one after another and ultrafiltration membranes, reverse osmosis, liquid-liquid extraction and high pressure liquid chromatic spectrums and other separation techniques are already in widespread application. China should adopt feasible measures to enhance research work in this area correspondingly.

Right now the instruments and equipment used in experimental research and industrial production in China are very backward. We should establish step by step a national industrial system to produce bioengineering instruments and equipment. In the short run it is essential that we import some of our instruments and equipment from abroad, but in the long run we must gain a foothold on the problem domestically. We must enhance the development and production of instruments and equipment and as quickly as possible form an industrial system on an advanced level.

As for training talented personnel, we should concentrate on training scientists and technologists at various levels, from high level down through middle and elementary levels. At the same time we must preserve the appropriate proportion of scientists and technologists in the various research orientations within the field of bioengineering, so as not to favor one at the expense of another. In addition we must promote academic exchange at home and abroad and augment scientific and technological information collection and research work.

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LIFE SCIENCES

DEVELOPMENTS IN NEUROSURGERY DISCUSSED

Beijing JIANKANG BAO in Chinese 14 May 85 p 2

[Article by Jia Zengfu [6328 1073 4395]: "The State of Neurosurgery Developments in China"]

[Text] In the wake of rapid growth in medical and health facilities nationwide, China's neurosurgical facilities have garnered great achievements.

Nervous system epidemiology is a new field in China. In 1983 the Beijing Institute of Neurosurgery cooperated with its various fraternal units nationwide to conduct an epidemiological survey of nervous system diseases among the 940,000 residents of 6 Chinese cities. The data showed the incidence of cerebrovascular disease to be much higher in China than abroad and indicated that it has become foremost among the three major causes of death. This thereby provides a strong basis for enhancing prevention and treatment of, as well as research on, cerebrovascular disease.

In the area of clinical treatment, in the past few years we have developed operative treatment of ischemic cerebrovascular disease. As of the end of 1982 there had been approximately 1,500 cases of intracranial and extracranial arterial anastomosis performed nationwide. Zhou Dai [0719 1486] and others at Suzhou Medical College First Teaching Hospital employed gradual clamping and obstruction of the arteria carotis interna and simultaneous engagement of the arteria termporalis superficialis--anastomosis of the arteria cerebri media to treat three cases of tumors in the sinus cavernosis section of the arteria carotis interna and giant tumors in the arteria carotis interna achieved satisfactory results. Professor Yu Shiying [0060 0013 5391] and others at Guiyang Medical College conducted intracranial and extracranial arterial anastomosis on 105 cases of paralysis, with a long term effectiveness of 96.4 percent. Now intracranial and extracranial arterial anastomosis has become one effective method of treatment for ischemic cerebrovascular disease. In addition to this, intracranial grafting of the omentum majus has also developed in the past few years as an operative method of treatment for the above disease. As of March 1981 a total of 205 cases had been performed nationwide. The long-term result is 92.16 percent effectiveness for the pedicle omentum majus graft and 5.33 percent for the free omentum majus graft.

Simultaneous with the above, intracranial operations have also achieved great results in the past few years. Professor Wang Zhongcheng [3769 1813 6134] and others at Beijing's Tiantan Hospital successfully performed at one time tumor pedicle clamping and obstruction of four arterial tumors in intracranial arteries and on the trunk of the arteria cerebri media. After the procedure arteriography showed that the arteria cerebri media and its branches were unobstructed: the arterial tumors had completely vanished. Thus they have gained excellent experience for China in handling several arterial neoplasms at once. Professor Chen Bingheng [7115 3521 1854] of Beijing Institute of Neurosurgery successfully achieved complete excision with a single cranial opening in four successive cases of bilateral acoustic nerve neoplasm, while also retaining full neural functioning. The results achieved by Luo Shiqi [5012 0013 4388] and others at Beijing's Tiantan Hospital using a highly difficult operation on post-ventricular tertius cerebri neoplasms has reached the advanced international level. The results of an analysis of the 150 open-cranium operations and 112 cases of microsurgery through the bucco-nasal sinus that were performed by Professor Wang Weijun [3769 4850 6874] and others at Beijing's Xiehe Hospital indicate that, due to the development of microsurgery, in the last 5 years the number of open-cranium operations on patients has increased by 6.7 times over the previous 20 years. The data also show that 85 percent of all microscopic adenomas of the an nei [7254 0355] pituitary gland can be totally or subtotally excised (53 percent and 32 percent, respectively). In addition there was a reduction in post-operative relapse and in the rate of recurrence, and there was an increase in the level of pituitary function restoration.

As far as treatment is concerned, intractable epilepsy has always been a thorny problem. The corpus callosum section developed in the past few years has opened up a new route to treatment of this disease. Tan Qifu [6223 0796 1381] and others at Nanjing Armed Forces General Hospital used microsurgery to treat seven cases of refractory epilepsy, all of which achieved satisfactory results. Li Wugao [2621 0839 2640] and Chen Jiurong [7115 0036 2837] and others at Shenyang's Chinese Medical College performed corpus callosum amputations to treat two cases of intractable epilepsy, with good results.

Simultaneous with our attainment of good success in clinical treatment, basic neurosurgical research has also yielded excellent results. Beijing Institute of Neurosurgery conducted an analysis of 9,063 cases of intracranial neoplasms that have been verified pathologically in the past 30 years. Every form of intracranial neoplasm, every kind of colloma and the incidence of congenital neoplasms were included in the analysis. The data represents the nation's most populous group and the patients hail from all over the country, therefore this survey has a certain guiding significance for the diagnosis of all types of intracranial neoplasm. Through cell fusion staining and immunochemical analysis, this institute in 1984 also successfully established a hybrid tumor system for human somatotropin. This is China's first domestic manufacture of a pituitary hormone monoclonal antibody, and it provides the conditions necessary for development of pituitary hormone (GH) research and somatotropin genetic engineering. In addition, the external culture and hormone assay of a human hypophysoma is another of this institute's most recent achievements. The culture method is more accurate than other methods, and the various kinds of

pituitary hormones that are difficult to distinguish in serologic assay or under the electron microscope can be detected using this method. This method is not disturbed by internal factors and can assist other methods in diagnosing hypophysoma where it is even more difficult to verify. With respect to arteriovenous vasotransplantation, Shen Jiankang [3088 1696 1660] and others at Nanjing Armed Forces General Hospital conducted comparative studies of arteriole and venule transplantation on the arteriae femoralis of white rats and rabbits, providing an ideal foundation for related clinical work.

In the past few years there has been initial success with the use of laser technology in the field of neurosurgery. Shanghai's Huashan Hospital, Xi'an Medical College First Teaching Hospital and Wuhan Medical College Second Teaching Hospital in succession launched CO_2 laser vaporization and cerebroma removal operations. Wang Wenzhang [3769 2429 0112] and others at the Second Military Medical College utilized a new type of photosensitive agent plus argon laser irradiation to treat cerebral tumors, and initial reports of results are good. Xu Qiwu [1776 0796 2976] and others at the Institute of Neurological Disorders at Shanghai First Medical College used a laser composed of YAG-CO_2 to combine irradiation of the brain with experimental vascular research, with good hemostyptic results.

Neuroelectric topographic mapping is a new technique launched in the past few years at Beijing Institute of Neurosurgery. It is capable not only of diagnosing intracranial morphological illnesses, it also can diagnose cerebral functional affections that cannot be discovered through CT, and it can make up for the inadequacies of CT and electroencephalograms. Analysis and comparison reveal that the diagnostic rate of this method is higher than that of the electroencephalogram, and its accuracy in conformance with CT and operative means is 96.6 percent. It has become a major neurosurgical inspection method.

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19 September 1985

AUTHOR: FANG Dingyou [2455 0002 6788]

ORG: National University of Defense Technology

TITLE: "The Computation of Transonic Nozzle Flow Field by a Time-Dependent Method"

SOURCE: Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 2, 1985 pp 10-18

TEXT OF ENGLISH ABSTRACT: The steady inviscid transonic nozzle flow is computed based on the time-dependent method. The Boundary-Fitted-Coordinates (BFC) system is adopted for generating a natural grid. The second-order MacCormack finite difference scheme is adopted for solving the governing equations. The wall boundary condition is computed from characteristic formulation. The reflection boundary condition is used to evaluate the physical flow variables at the center line. The results from this study agree very well with the test data.

AUTHOR: ZHANG Yaoke [1728 5069 4430]
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ORG: ZHANG of the Computing Center, Chinese Academy of Sciences; SHEN of Qinghua University

TITLE: "Numerical Simulation of Three-dimensional Transonic Flow in Turbomachinery"

SOURCE: Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 2, 1985 pp 29-36

TEXT OF ENGLISH ABSTRACT: In this paper our purpose is to improve a former study. According to previous work, we make use of the correct radial momentum equation in integral form. Also, instead of conservation of enthalpy used previously, we use the unsteady adiabatic energy equation for the inviscid perfect gas. As an actual example, comparison of numerical results between Denton's computing scheme and our correction scheme has been made. Computational results show that numerical solutions of three-dimensional transonic flow attained by our program have the correct trend and convergence is good. For the computational region of the transonic turbine blade mentioned above, we use 44 x 7 x 7 = 2156 gridpoints. Computing time is about 60 minutes CPU on an IBM 4341.

AUTHOR: XIANG Yansun [0686 5888 5549]

ORG: Chinese Aerodynamic Research and Development Center

TITLE: "The Numerical Calculation of the Pressure Distribution of Sharp Edge Slender Wings with Leading or Side Edge Vortex Separation"

SOURCE: Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 2, 1985 pp 37-43

TEXT OF ENGLISH ABSTRACT: In this paper, a convenient method is developed to calculate the aerodynamic characteristics and pressure distribution of slender wings with leading or side edge vortex separation in the incompressible flow. By use of a vortex lattice method, the leading edge Kutta condition is employed to determine the strength of the vortex sheet, and an equivalent concentrated vortex line is adopted to simulate the leading edge vortex. Various kinds of slender wings are calculated using the method, and results show good agreement with other methods and tests until the vortex breakdown.

AUTHOR: LIN Baozhen [2651 0202 4176]
SHEN Mengyu [3088 1322 5148]
ZHOU Sheng [0719 4141]

ORG: LIN of the Chinese Academy of Space Technology; SHEN of the Department of Engineering Mechanics, Qinghua University; ZHOU of the Department of Jet Propulsion, Beijing Institute of Aeronautics and Astronautics

TITLE: "The Characteristic Compatability Conditions on Boundary Points Applied to Time-Marching Methods for Transonic Flow Past Plane Cascades"

SOURCE: Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 2, 1985 pp 44-50

TEXT OF ENGLISH ABSTRACT: In this paper the characteristic compatability system that is applied to the boundary points is derived under universal form. The methods giving the boundary conditions for flow past plane cascades are discussed by characteristic theory. The numerical tests of the boundary conditions are done according to different approaches and comparisons of their numerical results are presented.

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WU Baogen [0702 1405 2704]
XIE Bangli [6200 6721 0500]

ORG: Institute of Mechanics, Chinese Academy of Sciences

TITLE: "Double Mirror Laser Interferometer for Visualization of Flow Field"

SOURCE: Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 2, 1985 pp 74-82

TEXT OF ENGLISH ABSTRACT: A double mirror laser interferometer has been designed and constructed. Compared with the Mach-Zehnder interferometer (MZI), it has such merits as higher intensity of interference information, better shock proofing, simpler structure and lower cost, and its interferograms can be evaluated quantitatively in the same way as those of MZI. In addition, its sensitivity in a large field of view is about twice that of MZI. The width and direction of the interference fringes can be adjusted easily and no harsh terms or complex adjustment is needed. This interferometer is suitable for interference visualization and quantitative analysis of most flow-fields.

In this paper the principles and characteristics of this instrument are discussed and some results of applications in practice are given.

AUTHOR: LIU Dehua [0491 1795 5478]

ORG: Chinese Aerodynamic Research and Development Center

TITLE: "Discussions of the Regular Behavior of the Longitudinal Dynamic Response of Aircraft During Variable Sweep Flights"

SOURCE: Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMIC SINICA] in Chinese No 2, 1985 pp 93-96

TEXT OF ENGLISH ABSTRACT: The regular behavior of the aircraft dynamic response and its relationship to the aerodynamics of the aircraft during variable sweep and accelerated flights are idscussed in this paper, and the mechanism for the regular behavior of the aircraft response is also analyzed.

It is pointed out that the decrease in incidence, flight-path angle and flight altitude at the initial time during the variable sweep and accelerated flight is the fundamental characteristic of the aircraft response, which is caused by the aerodynamic center moving backward and thus an increase in static stability. It is also pointed out that the dynamic response at the initial time can be predicted using the varying rate, at the time when the sweep angle begins to vary, of the static stability to the sweep angle, i.e., $\partial m_z^{cy}/\partial \chi$.

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CSO: 4009/272

Chemistry

AUTHORS: LIU Hengchuan [0491 1854 2796]
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TITLE: "Synthesis of a New Reagent--Nitrophosphonazo-mN and Its Application in the Spectrophotometric Determination of Rare Earth Elements"

SOURCE: Beijing HUAXUE SHIJI [CHEMICAL REAGENTS] in Chinese Vol 7 No 1, 28 Feb 85 pp 1-5

ABSTRACT: Nitrophosphonazo-mN (2-(4-nitro-2-phosphonophenylazo)-7-(3-nitrophenylazo)-1,8-dihydroxy-3,6-naphthalene disulfonic acid, NPA-mN) was obtained by coupling nitrophosphonazo-I and m-nitrobenzenediazonium chloride in basic medium at low temperature.

This reagent forms a stable blue complex with rare earth elements in strong acidic medium. The color reaction takes place rapidly. It has a large contrast and high sensitivity. The value of molar absorptivity is found to be 8.1×10^4 $\ell \cdot mol^{-1} \cdot cm^{-1}$. Beer's law is obeyed in the range of 0-12.5 μg Ce per 25 ml. Ten parallel determinations of 10 μg of Ce give a standard deviation of 3.76×10^{-3} and the coefficient of variation is 0.87 percent.

The reagent may be used for the spectrophotometric determination of Ce subgroup elements in the presence of Y subgroup elements which can be masked by oxalic acid. (Paper received on 13 September 1983.)

CSO: 4009/1111

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ORG: Ma of the Yichang Institute of Geology and Mineral Resorces, Ministry of Geology; Rong and Pan of the Department of Chemistry, Zhongshan University

TITLE: "Spectrophotometric Determination of Micro Amount of Palladium With 5-(5-bromo-pyridylazo)-2,4-diaminotoluene (5-Br-PADAT)"

SOURCE: Beijing HUAXUE SHIJI [CHEMICAL REAGENTS] in Chinese Vol 7 No 1, 28 Feb 85 pp 17-19

ABSTRACT: A sensitive and highly selective spectrophotometric method for the determination of palladium is based on the reaction of palladium with the cited reagent to form a water soluble complex which is stable in a medium of 0.5-2.5M HCl.

Its molar absorptivity is 1.5 x $10^5 \cdot \ell\ mol^{-1} \cdot cm^{-1}$ at 580nm. The molar ratio of palladium to 5-Br-PADAT is 1:1. Beer's law is obeyed for 0.01-0.6 ppm of palladium(II).

The method has been used in the determination of palladium in ores with satisfactory accuracy and precision. (Paper received 12 August 1983.)

CSO: 4009/1111

Computers

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TITLE: "The Numerical Methods of Calculation the Flow About Wings at Three-Dimensional Steady and Nonsteady Transonic Speeds"

SOURCE: Tianjin TIANJIN DAXUE XUEBAO (ZHENG KAN) [JOURNAL OF TIANJIN UNIVERSITY (SUPPLEMENT)] in Chinese No 2 (Mechanics) Dec 84 pp 16-24

ABSTRACT: Based on the finite difference equations obtained from small perturbation theory and through a hyperbolic tangent transformation which maps the physical space into a cube, the three-dimensional steady and non-steady transonic flows about wings had been computed. The use of relaxation method can reduce the demand on computer memory, and experience have been obtained through test runs. Calculated results are generally in good agreement with wind tunnel tests. (Paper received on 17 April 1984.)

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19 September 1985

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TITLE: "High Resolution Si(Li) X-Ray Detector"

SOURCE: Beijing HEDIANZIXUE YU TANCE JISHU [NUCLEAR ELECTRONICS AND DETECTION TECHNOLOGY] in Chinese Vol 5 No 3, May 85 pp 139-142

TEXT OF ENGLISH ABSTRACT: This paper describes the fabrication technology of the GL1221 type Si(Li) X-ray detector core and the pulse light feedback coded preamplifier which is fitted on the detector. The energy resolution of the detector system is 165 eV (at 5.89 keV Mn-Kα X-ray), the counting rate is 1020 cps and the electronic noise is 104 eV. Its specifications have attained the business level of foreign products of the same kind.

AUTHOR: SHAO Peng [6730 7720]

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TITLE: "Display Terminal Interface for Nuclear Data Analysis System"

SOURCE: Beijing HEDIANZIXUE YU TANCE JISHU [NUCLEAR ELECTRONICS AND DETECTION TECHNOLOGY] in Chinese Vol 5 No 3, May 85 pp 143-147

TEXT OF ENGLISH ABSTRACT: We have designed a display terminal with a resolution matrix of 512 x 256. The display interface consists of a synchronous generator, multiplexer, display RAM, data buffer register, character generator, shift register and video mixer. Model MIC-80 microcomputer controls the display interface with address bus, data bus and control bus. The display interface can apply to the computer's character terminal or to the display terminal of multichannel data acquisition and process system based on the microcomputer.

AUTHOR: ZHAO Yamin [6392 0068 3046]
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TITLE: "Development of a Method for Sampling Tritiated Water Vapor in Air by Silicon"

SOURCE: Beijing HEDIANZIXUE YU TANCE JISHU [NUCLEAR ELECTRONICS AND DETECTION TECHNOLOGY] in Chinese Vol 5 No 3, May 85 pp 148-153

TEXT OF ENGLISH ABSTRACT: A simple method for sampling tritiated water vapor in air with silicon get has been developed. Two formulas for estimating the tritium average concentration in the air sample have been established. One does not involve the term of the silicon gel sampling efficiency, and is suitable for rapid sampling or sampling in which the silicon gel is directly exposed to the sampling air. The other does not involve the relative humidity of the sampling air and is suitable when more accurate results are desired.

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ORG: Beijing Nuclear Instrument Factory

TITLE: "Influence of Frequency on CV Characteristics of Semiconductor Surface Barrier Detectors"

SOURCE: Beijing HEDIANZIXUE YU TANCE JISHU [NUCLEAR ELECTRONICS AND DETECTION TECHNOLOGY] in Chinese Vol 5 No 3, May 85 pp 158-161

TEXT OF ENGLISH ABSTRACT: Under reverse bias if the frequency of a small AC signal exceeds a particular value, the junction capacitance of the Au-Si surface barrier detector will decrease. In this paper the experimental results of the frequency influence on CV characteristics are discussed and analyzed. The highest available threshold frequency, f_{th}, depends on the electrical field E in the semiconductor depletion zone. The experimental relationships among f_{th}, E, resistivity and voltage are given. At room temperature f_{th} can be 1-4 MHz.

AUTHOR: LIU Yongyue [0491 3057 6885]

ORG: Institute of High Energy Physics, Chinese Academy of Sciences

TITLE: "The Peak Pressure Formula for the Acoustic Effect of Energy Charged Particles"

SOURCE: Beijing HEDIANZIXUE YU TANCE JISHU [MUCLEAR ELECTRONICS AND DETECTION TECHNOLOGY] in Chinese Vol 5 No 3, May 85 pp 166-169

TEXT OF ENGLISH ABSTRACT: The dependence of the time structure and amplitude of the acoustic pulse on the heating time and response time of hydropyone are analyzed. The form of the time dependent term of the acoustic pressure is established. The peak pressure formula which agrees well with the experimental data in both the near- and far-fields is obtained.

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Mathematics

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TITLE: "Identifying the Unknown Boundary Condition--Estimation of Float Surface Temperature in a Floated Gyroscope"

SOURCE: Beijing XITONG KEXUE YU SHUXUE [JOURNAL OF SYSTEMS SCIENCE AND MATHEMATICAL SCIENCES] in Chinese Vol 4 No 3, Jul 84 p 182

ABSTRACT: The stationary temperature field in a floated gyroscope is described by a second order elliptic system, where the float surface temperature is unknown. Making use of Lions function space optimization method, we give a set of formulae to identify the unknown boundary condition of the elliptic system. Furthermore, we prove that the identified boundary condition is unique in some admissible set by means of measuring the temperature on the part of the gyroscope hull. (Paper received on 7 December 1983.)

CSO: 4009/1088

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TITLE: "A Simple Proof of Iterated Limit for Variation Diminishing Operator of Spline Functions"

SOURCE: Beijing XITONG KEXUE YU SHUXUE [JOURNAL OF SYSTEMS SCIENCE AND MATHEMATICAL SCIENCES] in Chinese Vol 4 No 3, Jul 84 p 172

ABSTRACT: The iterated limit for the variation diminishing operator of spline functions was determined by Hu and Xu by using the related results of Markov chain. In this paper, by the method used in Ref 3, not only the proofs in Refs 1 and 2 are considerably simplified, but also the convergence rate of the iterated limit is given. Furthermore, the error estimate given here for the cubic spline on a uniform partition in a certain sense is the best. (Paper received on 15 November 1983.)

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CSO: 4009/1088

JPRS-CST-85-032
19 September 1985

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ORG: Institute of Atomic Energy, Beijing

TITLE: "Mass Distribution in 8.3 MeV Neutron-Induced Fission of ^{238}U"

SOURCE: Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 2, May 85 pp 97-105

TEXT OF ENGLISH ABSTRACT: Forty-six mass chain yields and two cumulative yields from ^{83}Br to ^{161}Tb are obtained for fission of ^{238}U induced by 8.3 MeV neutrons. Of these, 41 are determined absolutely. Fission product activities are measured by Ge(Li) γ-ray spectrometry of irradiated ^{238}U foils and by chemical separation of the fission product elements followed by γ or β counting. The ^{238}U targets are attached to a double-fission chamber containing two thin, standardized deposits of ^{238}U to monitor the fission rate absolutely. ^{113}Ag is measured for the first time. A mass distribution curve is given. The present yields are compared with values given in the literature.

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MENG Jiangchen [1322 3068 6591]
et al.

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TITLE: "Detailed Investigation of Correlation Properties in Long Range Alpha Particle Accompanied Fission of ^{252}Cf"

SOURCE: Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 2, May 85 pp 112-116

TEXT OF ENGLISH ABSTRACT: This experiment investigates the variation of the correlation between the average energy of long range α-particles (LRA particle) and the fragment mass ratio with the total kinetic energy of the fragments, and the dependence of the correlation between the average energy of the LRA particles and the total kinetic energy of the fragments on the fragment mass ratio. In addition, other correlations in LRA accompanied fission are also given.

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TITLE: "Elastic Scattering of the Intermediate Energy Kaon Mesons on the Nuclei and Coulomb's Effects"

SOURCE: Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 2, May 85 pp 124-132

TEXT OF ENGLISH ABSTRACT: In the frame of the eikonal multiple scattering theory, using the basic parameters given by the authors, the elastic scattering of the intermediate energy kaon mesons on ^{12}C and ^{40}Ca are studied. The Coulomb effect is calculated, too. The results are in agreement with the experimental data. The Coulomb effect does not only enhance the small angle differential cross section, but it also fills up the dip of the differential cross section.

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TITLE: "The Nucleon-Meson Vertex Structure on the Basis of Nonrelativistic Quark Model. II. The Nucleon-Meson Coupling Constants and the Form Factors"

SOURCE: Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 2, May 85 pp 133-139

TEXT OF ENGLISH ABSTRACT: Based on the nonrelativistic quark model, the nucleon-meson vertex coupling constants and the form factors are discussed by using the transition potential of one-gluon exchange with the production of a quark-antiquark pair which is formed from quark-gluon interaction. The nucleon-meson coupling constants, obtained by using the generator coordinate method, can fit the experiment data quite well. The contribution of the quark momentum-dependent term in the transition potential to coupling constants is important. The nucleon-meson vertex form factors are also given and discussed.

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TITLE: "A Global Analysis of Int[illegible]l Cross Section Calculations with the Microscopic Optical Potential"

SOURCE: Beijing YUANZIHE WULI [CH[illegible]SE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 2, May 85 pp 154-160

TEXT OF ENGLISH ABSTRACT: In this [illegible]aper the microscopic optical potential derived from Skyrme interactions ([illegible] is applied to the global calculations of the integral cross section for neutron reactions of various even-even target nuclei. The neutron total, [illegible]stic scattering and non-elastic cross sections calculated with S-M[illegible] analyzed and compared with available and independent experimental data [illegible] as that calculated with Greenlees' phenomenological potential. The g[illegible] analysis shows that original Skyrme forces, such as GS2 and SKa, can f[illegible] experiments of the total cross sections in the neutron energy reg[illegible] 2-100 MeV, without adjusting any parameters, for nuclei ranging fro[illegible] to ^{242}Pu quite well. The theoretical deviation of the calculated result[illegible] the experimental fitting curves is no more than 20 percent, which is [illegible]rable to the results based on Greenlees' global phenomenological potential [illegible] even better than Greenlees' results for light nuclei. Thus, it is sho[illegible]t S-MOP has a capability for predicting the integral cross sect[illegible] a wide range of energy and nuclei cases.

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TITLE: "The Application of a Bridge with Variable Ratio to Feedback Electron Linac"

SOURCE: Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 2, May 85 pp 175-181

TEXT OF ENGLISH ABSTRACT: This paper describes the performances of a 20MeV feedback electron linac with a magnetron of 4.8 MW output power as a source. The accelerating structure is the same as one completed for therapy, but the feedback bridge of fixed ratio n=1 is replaced by one of variable ratio so that optimum efficiency can be reached at different beam loadings. When the accelerating current is 500 mA the pulse beam power is over 3 MW, the efficiency is more than 75 percent and the energy spread is less than 10 percent. Thus it can satisfy the wide-ranging demands in applications to physics research, material science and industry.

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CSO: 4009/279

Physical Chemistry

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TITLE: "Experimental Determination of Stereochemical Structures of D_3^+ and H_3^+"

SOURCE: Chengdu SICHUAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF SICHUAN UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese No 2, 1985 pp 98-100

ABSTRACT: The measurements on the stereochemical structures of D_3^+ and H_3^+ molecular ions are reported. It makes use of the Coulomb explosion of fast molecular ions. It is shown that the structures of D_3^+ and H_3^+ are equilaterally triangular in shape. The mean value of most probable internuclear separations of H_3^+ and D_3^+ are determined to be 0.98±0.03Å and 0.93Å respectively. (Paper was received on 5 September 1985.)

CSO: 4009/1103

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19 September 1985

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TITLE: "Kinetic Theory of Tearing Mode in a Plasma Torus with Elliptical Cross Section"

SOURCE: Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 5 No 2, 15 Jun 85 pp 65-76

TEXT OF ENGLISH ABSTRACT: In Catto et al.'s work, kinetic modification to the tearing mode in the banana regime was considered and the contribution of the electrons from the trapped and untrapped velocity-space boundary layer to the current was obtained. In light of their idea, we study the effect of elliptical geometry on the tearing mode. Starting from the Fokker-Planck equation with a Lorentz collision operator, we have calculated the growth rate of tearing mode instability by using both the Ψ and $E_{\parallel}$ constant approximations.

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TITLE: "Stripping H^--Ion by Using Strong Magnetic Field to Obtain Neutral Beam"

SOURCE: Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 5 No 2, 15 Jun 85 pp 77-83

TEXT OF ENGLISH ABSTRACT: The ionized lifetime of travelling hydrogen negative ions with high velocity in a uniform magnetic field is calculated by using an improved perturbation theory. The choice of the H^--ion wave function and the normalization of the wave function in a continuous state are discussed. By using the Rotenberg-Stein wave function with five parameters a numerical calculation is performed, the results of which are compared with those from experiments by G.M. Stinson, et al.

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TITLE: "Radiation Patterns of Open Waveguide in Electron Cyclotron Resonance Heating"

SOURCE: Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 5 No 2, 15 Jun 85 pp 84-91

TEXT OF ENGLISH ABSTRACT: This paper describes the computation of directional microwave patterns radiated from open waveguides to plasma in electron cyclotron resonance heating by gyrotrons. The theoretical derivation is presented briefly. The E- and H-plane direction patterns of an open circular waveguide for the H^{0}_{01}-mode at wavelength λ=2 cm and for the H^{0}_{02}-mode at wavelength λ=8 mm are given, as well as the same patterns of an open rectangular guide for the $H^{\square}_{10}$-mode at wavelengths of λ=2 cm and 8 mm.

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TITLE: "The Influence of Rate Coefficients and Metastable States on Ionization Equilibrium and Radiation Losses from Oxygen"

SOURCE: Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 5 No 2, 15 Jun 85 pp 92-97

TEXT OF ENGLISH ABSTRACT: Calculated results of ionization equilibrium and radiation losses for oxygen are presented as functions of electron temperature. These calculations are based on the corona model. In order to study the influence of rate coefficients on ionization equilibrium and radiation losses, we used several different formulae for rate coefficients and included metastable states: He-like $OVII_{1S_2S^3S}$, Be-like $OV_{1S^2_2S_2P^3P}$, B-like $OV_{1S^2_2S_2P_2{}^4P}$.

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TITLE: "FIR-Laser Scattering from C e Electron Density Fluctuation"

SOURCE: Chongqing HEJUBIAN YU DENGLI I [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 5 No 2, 15 Ju 98-102

TEXT OF ENGLISH ABSTRACT: In this p measurement of the driven collective electron density fluctuat e ion cyclotron range of frequencies (ICRF) on UCLA's Microtor ar infrared (FIR) laser scattering is presented and the result nalyzed. The experimental results agree with the fast wave mode conversi ry in a two-ion species plasma. The FIR-scattering system used in the ents is also described. Finally, work to be studied in the future is b iscussed.

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TITLE: "Design of Electromagnetic Trap"

SOURCE: Chongqing HEJUBIAN YU DENGLIZITI WULI [NUCLEAR FUSION AND PLASMA PHYSICS] in Chinese Vol 5 No 2, 15 Jun 85 pp 108-113

TEXT OF ENGLISH ABSTRACT: The design of an electrostatically plugged cusp plasma confinement system is presented. The basic design parameters include a magnetic field at the electrode of 10 kG, 10 kV for the plug voltage, a plasma density of about 10^{12} cm^{-3}, 0.5 keV ion temperature and a confinement time of longer than 5 ms.

This system can be used to study the plasma accumulation and heating, potential shielding and the electrostatical end plug of axial symmetric tandem mirrors.

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